The Romance of Mining

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Containing Interesting Descriptions of the Methods of Mining for Minerals in all Parts of the World

By

Archibald Williams

Author of "The Romance of Modern Invention"
"The Romance of Modern Engineering"
"The Romance of Modern Locomotion"

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CHAPTER I

INTRODUCTORY

The Ages of Man—The Stone Age—The Copper Age—The Bronze Age—The Iron Age—The Steel Age—The discovery of gold, copper, lead, silver, quicksilver, and zinc—Iron and the smiths—Why iron was found so late—Its effects on civilisation—Coal—The precious metals and their influence on exportation—Metallurgy and science—Metallurgy and mechanics—The romance of mining—Dangers of mining—The scope of this book.

ANY writer on mining in its general aspect is, when casting about for a starting-point, driven to express what others have said before him—that the history of mining is the history of civilisation. If we try to penetrate into the period when metals were unknown to, or at least unused by, man, all we find of his arts is a few rough scratches on a cavern wall and some stone implements of defence and offence. So we call the era—covering thousands, tens of thousands of years, may be—during which the cave dweller depended for his livelihood on his power of fashioning flints, the Stone Age; synonymous in our minds with a dark, brutish existence of a creature just sufficiently more intelligent than the

"beasts of the field" to survive their attacks and to live by destroying them.

The ancients, who looked backwards rather than forwards in search of an ideal existence, spoke of the dawn of history as the Golden Age, the epithet being used metaphorically. All was then peace, plenty, and content. Strife between man and man, between nation and nation, had not yet arisen to mar human existence. Arguing from the social deterioration of their own time, they concluded that far back in the past men must have been of a far nobler stamp, and their lot cast in much more pleasant surroundings.

To-day we know too much to take refuge in such imaginations. While deploring the decay of time-honoured institutions and the virtues of the "good old times," we look confidently forward; and, were we given the choice, should not like to antedate our existence by even one hundred years. From the vantage-ground of knowledge we see that mankind has steadily advanced in spite of temporary set-backs, fighting circumstances ever more successfully by means of the weapons which the Arts and Sciences enable him to forge.

The importance of metallurgy is shown by the very fact that, when we wish to divide human history into a few periods, we fly to the metals as the standards by which to measure man's industrial development. The Copper Age succeeds the Stone Age; then tin is found, and the Bronze Age begins.

After the Bronze the Iron Age; and, last of all, we have the Steel Age, in which we live; though even at the present day there are, in different parts of the world, races still passing through the earlier Ages.

The metals serve three important ends. They supply man with the means of making life beautiful; secure; and comfortable.

The first metal to be discovered was probably gold, which exists in its native, or pure, state in many countries, lies on the surface, attracts the eye, and can be easily secured. What nation first set value by gold we cannot say, but we may reasonably conjecture that the primitive folk, even of the Stone Age, may have beaten this metal, valueless for tools or weapons, into decorations. So that, in one sense, the Golden Age was contemporaneous with the dawn of civilisation. The value of gold arose only when other metals had been added to the list of those mined and worked.

Copper, also found pure—though usually combined with other elements—must have been known to man at a very early date. By itself, its uses were limited, but when tin was discovered and alloyed with it, the manufacture of bronze altered the history of nations. The stone-users were no match for invaders armed with bronze weapons tempered to extreme hardness; and where stone encountered metal, metal won. Civilisation had now taken a long stride forwards. Bronze could be used for the arts of peace as well, being fashioned into tools,

agricultural implements, ornaments, and money. So well did the alloy serve man that for long ages he was content with nothing harder and more stubborn. When the Spanish conquerors invaded Mexico in the sixteenth century they found the Aztecs quite ignorant of the uses of iron; an ignorance which made possible the subjugation of a great race by a mere handful of bold adventurers.

After bronze came lead, silver, quicksilver, and zinc. Silver was probably discovered at the same time as lead, since the two metals are often found together. This fact caused the alchemists of the Middle Ages to regard lead as the "mother of silver," and to endeavour to transmute the baser into the more precious metal. Quicksilver, like lead and silver, is commonly found in combination with sulphur, which can be driven off by heat; and, whether discovered accidentally or otherwise, was used by the ancients as a solvent for gold.

Who first forged iron must ever remain a mystery. Tubal Cain is mentioned in the Book of Genesis as "an instructor of every artificer in brass and iron." He may have lived 3000 years B.C. The African natives seem to have been acquainted with the use of iron for time immemorial, perhaps long before the days when, in Greece, iron was offered as a prize to the victor in athletic games. The importance of iron, its utility for warlike as well as peaceful purposes, soon won it recognition. The early workers were defined under the names of Vulcan, Hephæstus,

Thor. Legends cling round the ancient smithies, associating the pioneer craftsmen in iron with supernatural powers. Wayland Smith, of the Berkshire Downs, has left behind him, in the pages of "Kenilworth," a reputation for magic. The family names of Smith, Smythe, Schmidt, Fabri, Lefevre, and their equivalents in many other languages, testify to the high rank of the armourer of the Middle Ages.

The late employment of iron is partly accounted for by the circumstance that, though one of the most widely diffused of minerals, it is never found pure except in the form of meteorites—lumps of iron which have suddenly descended upon the earth from the abysses of heaven. The earliest iron tools were probably made from these "gifts of the gods," which have been found in various sizes ranging from a few ounces up to many tons. Iron ore is so little suggestive of the metal it contains that an inexperienced eye would never connect it with the iron and steel of commerce. And even when the relationship had been established by the ancients the extraction of the metal from its matrix was a matter of great difficulty, on account of the numerous impurities of the ore and the high temperature needed for its reduction. We may still see in various parts of the world—China, Africa, the Malay Peninsula—the primitive methods used to separate the iron; a hearth blown by the winds or a pump of the simplest form; and the beating on the anvil of a heated metal ball to squeeze out the impurities. Iron thus obtained was

very valuable. Early warlike nations used it only for the "business edge" of their weapons, which were otherwise of copper or bronze.

Just as bronze overcame stone, so iron vanquished bronze in battle. The Romans, and, later, the Alchemists, called iron Mars. In the Bible we read how the Philistines, after their conquest of the Israelites, carried off all the smiths. "There was no smith found throughout all the land of Israel; for the Philistines said, Lest the Hebrews make them swords and spears. But the Israelites went down to the Philistines, to sharpen every man his share, and his coulter, and his axe, and his mattock." Gibbon tells us that the Turks owed their position as a powerful invading nation to the iron which, as slaves, they fashioned for their lord, the great Khan of the Geourgen. To quote his own words, "Their servitude could only last till a leader, bold and eloquent, should arise, to persuade his countrymen that the same arms which they forged for their masters might become, in their own hands, the instruments of freedom and victory. They sallied from the mountains (A.D. 545); a sceptre was the reward of his advice; and the annual ceremony, in which a piece of iron was heated in the fire, and a smith's hammer was successively handled by the prince and his nobles, recorded for ages the humble profession and rational pride of the Turkish nation." From that time onward victory has declared for the nations who have known how to combine discipline and

strategy with invention in the employment of iron. The Roman's short stabbing sword and protected shield against the shieldless barbarian; the armour-clad Spaniard against the naked Mexican; the fire-arms of Europe against the spear, arrow, and club of savages; the armour-plated warship against the "wooden walls"—in every case iron suitably fashioned wins the day. Even among highly civilised nations every advantage of metallurgical science is eagerly seized to strengthen defences and make weapons more deadly. Mere numbers do not now prevent defeat. Steel plates must be of the toughest; cannon and rifles must belch out the greatest possible number of missiles with the greatest possible accuracy. The mechanism of war must be reliable in every way. As M. Simonin wrote some decades ago, "In the contests which will unhappily long continue to take place, victory will henceforth generally remain with those who produce steel in the largest quantity and of the finest quality,"—words which were echoed by Mr. Andrew Carnegie when he said that predominance must be in the hands of the nation which can manufacture the cheapest ton of steel.

Our age, the Steel Age, could not be better named. Whichever way we look, steel confronts us. We move over it, shaped as rails or bridges. It enters more and more into the construction of our houses. The machinery which transports us from place to place, clothes us, feeds us, caters for our luxuries, is wrought from steel. And the wealth of nations

is derived chiefly from steel, either directly or indirectly.

Hand in hand with steel advances coal, without which it would be impossible to make full use of the metal. Steam-power waits on both. In fact, the triumvirate of steel, coal, and steam mutually support one another. Steam raises coal; coal smelts iron ore; iron ore yields material for the steam-engine; and so round the circle again. So great is the part played by coal in modern civilisation that the "bottled sunshine" of past ages may claim almost equally with steel to give a name to the present period in the history of mankind.

Enormous as has been the effect of iron on the fortunes of human society, we cannot forget the importance of the intrinsically more precious metals. Their unalterability, their beauty, and their variety have won them a place in our regard which, so far as we can see, nothing will ever be able to diminish. Associated as silver and gold have been with princely magnificence, they appeal to our æsthetic sense. The figures which stand out from history often, in part at least, owe their fame to the glamour of great wealth. What more striking personage has been immortalised by Holy Writ than King Solomon, in whose days silver "was nothing accounted of"; whose palaces and thrones were decked with gold; whose argosies sailed home laden with the gold of Ophir? The precious stones and marvellous riches which loom so largely in the "Arabian Nights" con-

tribute as much as personal adventure to the fascination of that book. Gold has been the magnet that has attracted the conqueror and the explorer. Time after time, India, the land of gold and diamonds, has had to bow to the invader, informed through travellers' tales of the wealth of the country. Gold took the Spaniards to Mexico and Peru. Gold drew hundreds of thousands to California, Australia, South Africa, Alaska. Unfurl the golden standard where you will, a huge army soon collects under the banner, and, after exhausting the minerals, turns to the agricultural development of the country. But for the reputed riches "of Ormuz and of Ind," exploration and colonisation of the world by Europeans would have been delayed for centuries.

The advance of science has been so greatly stimulated by metallurgy, and in turn metallurgy owes so much to scientific discovery, that we can hardly conceive of the one without the other. The alchemy of the Middle Ages, which vainly strove to change the baser into the nobler metals, laid the foundations for modern chemistry, which helps on the one hand to trace and extract metal from its ore, and on the other shows how metal may serve mankind in a thousand ways. The influence of mining on mechanical arts is no less striking. Out of the ladder and bucket has gradually been evolved the winding engine which whirls men and ore at twenty miles an hour from the depths of the

earth. The air or water-driven drill has replaced the stone or bronze hammer of the ancient miner. Electric lamps have ousted in large degree the candle and flickering oil-boat. Tramways do with ease what once caused basket-carrying men much toil and pain. The mechanical coal-cutter does the work of a hundred picks. Dynamite blasts into fragments huge masses that formerly would have been cleft laboriously with wedges. In spite of his conservatism the miner finally adapts to his use any invention which has proved beneficial to those who work on the earth's surface. And in return he has shown how mountains may be burrowed through for the passage of the locomotive. The Simplon Tunnel and the prehistoric underground galleries of Italy and Spain are more closely related than one may think.

To those who can see romance in industry, what a field does mining open! The story of the metals is bound up with phenomenal individual success, and equally gigantic failures. In a day the pauper becomes a prince, and he who fancied himself a prince finds himself a pauper. A humanity which takes pleasure in risking wealth on the cast of dice, on the running of a horse, or on the quotations of the Stock Exchange, cannot but be enthralled by the sudden ups and downs inseparable from the exploitation of new mines and virgin countries. Who has not, at one time or another, felt the desire to take pick and shovel and go on the trail of the miner

in the hope that he may prove a Marshall, a Hargraves, a Godoy, a Gould, or a Drake? From every corner of the globe come sensational, and often true, stories of men who in a lucky moment have grasped a secret worth millions of pounds. The world is large, and for every fortune that has been made a hundred still remain for the prospector.

Even when wealth has to be won by continuous and quite everyday work at the point of drill and pick the conditions of life are such as to appeal to the imagination. The great brotherhood of miners—the sturdy Cornishman, the lithe Italian, the stubborn, superstitious German, the hardy, sombreroed Asturian, the Chilian *barratero*, calm and impassive, the excitable Frenchman, the thrifty, patient Chinaman—is surrounded by perils and hardships. It was not without reason that the miners of the Harz peopled their mines with malicious gnomes, and prayed to Saints Nickel and Kobold before descending into the depths. Fire, water, poisonous gases, falling roofs, breaking ropes and ladders, are the terrors which the miner faces without thought as part and parcel of the risks of his calling. Yet for the outsider the bravery and resource shown by the "toilers of the deepest deep" in the presence of disaster help to weave a romance as real as that of the battlefield. And that, in spite of its hardships, mining has a fascination for the worker, is proved by the unwillingness of a miner to relinquish his calling in favour of any other.

The Romance of Mining

The following pages, while touching the chief branches of the mining industry, must necessarily omit reference to many of the great treasure-houses of the world. Special prominence has been given to the precious metals, because their discovery and working has witnessed the most stirring scenes in mining life. As Mr. Fossett writes in his "Colorado": "There has been a fascination and romance attending the search of the precious metals, and time intensifies rather than diminishes the feeling. Under the magic influence of gold and silver discoveries a spirit of enterprise has been engendered that has brought about the accomplishment of results as unexpected as they were grand and wonderful. The wilderness is peopled, states are founded, and almost an empire established where the presence of civilised man was unknown but a few years ago." The reader will also be glad to hear of the source and supply of some of the most valuable varieties of jewels, round which romance clings even more abundantly than round the metals, since individual stones have had their histories. We have the whole world to roam over; so excursions are made into those spots where typical or prominent instances of the mining of various minerals are to be found. Mining, here used in its widest sense, includes operations on the surface as well as those underground; and extends to those substances which are extracted from the earth without recourse to shafts and tunnels.

Introductory

Enter a jeweller's shop and take note of the minerals ranged around. Could they speak, what stories they might have to tell! There is the gold of many countries; the silver of Mexico, Nevada, Spain, Bolivia, Mexico; the tin of Cornwall and Malacca; the copper of Lake Superior; the platinum of Colombia or the Ural Mountains; the diamond of Brazil and Griqualand; the ruby of Burma; the turquoise of Persia; the emerald of Peru; the sapphire of Ceylon. Even in an ironmonger's the metal displayed hails from many lands—the British Isles, France, the United States, Germany, Austria, Russia, Sweden, Italy, Spain, and Siberia. In the stonemason's yard English sandstone jostles Italian marble and Scotch granite and Welsh slate. On the grocer's shelves English salt stands close to Sicilian sulphur. Let us go and see how these diverse substances were discovered; how they are won to the use of mankind; how the people live who exhume them; and what are and have been the difficulties encountered before Nature's mineral riches are poured by land and sea into the lap of civilisation.

CHAPTER II

ANCIENT MINING

Features of early mining—Riches of the ancients—The Egyptian mines—The earliest European miner—The Etruscan mines of Campiglia—The Phœnicians—Zimbabwe—The Romans as miners—The Romans in Britain—Aztecs and Peruvians—The development of mining methods—Ventilation—Gunpowder—Hoisting devices—Comparative comfort of modern miners.

BEFORE embarking on detailed accounts of the various branches of mining as conducted to-day, we shall do well to consider briefly the earliest stages of the industry, when it was being gradually evolved and organised by the old and great peoples of the earth.

Three facts seem to stand out clearly in respect of ancient mining: (1) That India was the centre, at least in the Old World, from which radiated the first advances in the science of extracting minerals, to pass successively through Egypt, Phœnicia, and the Archipelago, to Greece and Italy, whence they penetrated to Germany, Gaul, and the British Isles; (2) that among the ancients mining was not considered honourable toil, and, therefore, had to be performed by slaves—hence a nation had to become a conqueror before it could set up as a mine-owner; (3) that gold was the metal to which the earliest

miners turned their serious attention, copper coming second, and tin third. As we have already noticed, iron made an appearance very late, when metallurgy had developed so far that the Egyptians and other races were able to perform many operations with bronze tools which, for lack of knowledge how to temper the copper alloy to a requisite hardness, we could not imitate to-day without recourse to steel.

We may safely assume that mining was practised in eastern countries for three or four thousand years before the Christian era. Gold, won from the earth by washing alluvial deposits, just as is still done in many localities, steadily accumulated in the royal coffers of a kingdom until, in order to put it to some practical use, it was fashioned into objects of worship or the paraphernalia of a court. "In Babylon there were three great statues of beaten gold, two of them 40 feet high, and the third probably of similar dimensions, though sitting. Besides these there was an altar, 40 feet long and 15 feet broad, covered with gold plates and several massive bowls and censers. From the weights given it has been calculated that the raw metal in these constructions weighed about 2,700,000 ounces, or about £11,000,000."[1] We know, too, that Darius was able to wring a yearly tribute of over £2,500,000 out of his satrapies. David and Solomon devoted huge quantities of the metal to the adornment of the temple and the royal palace. The Athenians reared

[1] *Cassier's Magazine.*

over their citadel an enormous gold and ivory statue of the goddess Athene. In the New World the same accumulation went on through the ages, there being no gold currency to absorb the gold, so that the Spanish conquerors on their arrival in Mexico and Peru found vast treasure worth a desperate struggle for its ownership.

It must not be supposed that the Old World as a whole, or even contiguous countries, kept abreast in the art of mining. As we can see at the present time, some races have retained the most primitive processes, while others have advanced. The Chinaman of the interior of China extracts his iron from its ore in the same way as his ancestors did before him for countless generations. The rock drill and ponderous ore-crushing stamp exist contemporaneously with the stone hatchet.

Therefore, in speaking of ancient mining, we should remember that its development was local and spasmodic, though the general tendency throughout the world was forwards.

We naturally look to the Egyptians for the earliest mining work that can be even approximately dated. The copper mines of Sinai are the most ancient of which history makes mention. According to documentary accounts they were worked from 5000 B.C. to about 1200 B.C. There still exist the tunnels, furnaces, crucibles, and parts of the tools used by these toilers of the dim past. That the Egyptians knew of iron thousands of years ago is suggested by

sculptures of what are supposed to be iron smelting furnaces, but as these particular sculptures do not date further back than 1500 B.C., the introduction of iron would, even if the treatment of that metal is indicated, still be very greatly posterior to the mining of copper ; and we are left to wonder how the Egyptians carved the great granite blocks that now attract tourists in crowds to the Valley of the Nile.

The earliest European workings may have been the Spanish. Among the copper lodes of the Asturias human skulls of a prehistoric type have been discovered near mining implements of flint. When metallurgy was dawning in the Italian peninsula, the old Etruscans drove galleries through the rocks of Campiglia, in search of copper. "There are," says M. Simonin in "Underground Life," "excavations large enough to hold a six-storied house with ease. These vast chambers communicate with each other by means of narrow galleries, or rather passages, in which a person can scarcely crawl. The barren rocks, left as rubbish or waste in the excavations, have hardened and become cemented together under the pressure of the overlying beds, and by the earthy débris of the mine. These artificial masses can only be broken by blasting, like those blocks of concrete which are thrown into the sea in the construction of breakwaters. The wooden props are still in place, rotted, or rather carbonised, by a sort of slow decomposition of the vegetable tissue ; all the smell they give out may be recognised as that of the

evergreen-oak and the chestnut, which are always grown in the country. Fragments of vases, lamps, and amphoræ, which are found in the rubbish, are connected with Etruscan art. Wedges and bronze picks have also been met with in the mines, affording proofs that these works date from a period when iron was not commonly used for ordinary purposes. . . . Enormous masses of rubbish cover the flanks of the mountains where the ancient pits have been opened, and over an extent of several miles follow two parallel courses marking the outcrops of the veins. In the valleys there are still enormous heaps of cinders on the very sites of the ancient foundries." Though these mines have not been worked for possibly 3000 years, they show a comparatively advanced stage of mining art. The very marks of the tools still remain in the rock, as fresh as if they had been made yesterday.

The Phœnicians played so important a part in the spread of civilisation through the Mediterranean countries, and even beyond the Pillars of Hercules, as the ancients termed the Straits of Gibraltar, by trading and exploiting the mineral deposits known to them, that we may pay special attention to their operations.

Before the Phœnicians first visited Spain the inhabitants had worked the silver, lead, and copper mines of Huelva, Cordova, Seville, and Malaga, in the southern parts of the peninsula. The Canaanitish traders, getting access to the coast direct, and to the

inland regions (generally called Tarshish) by the Guadalquiver, drove a profitable trade with the natives in the metals mentioned. As soon as they had established themselves firmly they either compelled the natives to work the mines for them, or imported slaves from their own territories bordering the Mediterranean. They must have obtained huge quantities of metal if Diodorus of Sicily is not exaggerating when he states that even the anchors of ships returning from Spain were of silver—a statement which reminds us of the silver cannon sent by Pizarro from Peru to Spain. The historian says further that "the avarice of the Carthaginians (Phœnicians) led them to seek for and work mines in all parts of the Peninsula, and that it was from this source they obtained the means with which to combat, and for a long period stubbornly resist, the ultimately superior forces of mighty Rome." It is, unfortunately, impossible to distinguish the Phœnician from the Roman operations which immediately succeeded them. But we may be sure that many thousand tons of copper, tin, and silver were extracted during the Punic occupation, the zenith of their activity probably being the period when Solomon sent his ships to Tarshish.

Naturally adventurous voyagers, the Phœnicians coasted round the Atlantic shores of Spain and France, and finally reached the westernmost part of England, where they did a brisk trade in tin with the savage Cornishmen. We shall refer to

this sphere of their activity more fully in a later chapter.

In Rhodesia, at Zimbabwe, are ancient ruins of great extent, and old mines from which large quantities of gold were extracted by the people that raised the huge fortress there. Legend has long associated this region with the Ophir of King Solomon; and Mr. Rider Haggard, in his "King Solomon's Mines," has drawn an imaginative picture of the excavations driven through the mountains in the time of that monarch. More recently fact has succeded fiction. Mr. Theodore Bent, after a careful examination of Zimbabwe and its surroundings, pronounced that during one period of its earliest history the Phœnicians occupied Rhodesia, and that to them are largely due the galleries and pits which can be counted by the thousand all over the country. The gold was not merely won from the "outcrops" of veins. Shafts were sunk to a depth of even 150 feet, and levels were driven from there along the veins. The Rhodesian miners also knew the use of fire to crack and splinter the rock, before attacking it with tools. They brought up the quartz, ground it in mills, and washed the particles of gold out of the rubbish in hollows still visible along the river bed. Bent found rows of crushing-stones and mortar-holes at which the African slaves wore out their miserable lives.

The gold thus obtained was smelted and cast in soapstone moulds for conveyance to the coast,

whence it probably went by sea to the Red Sea, and overland to Palestine. When at last the Phœnicians had to quit their South African colony they walled-up the entrances to some of the mines before they went. "Outside others, heaps of quartz stand stacked ready for removal. Tools are found at the bottom of shafts, as if abandoned by the workers in a panic, curious flint tools, stone axes and wedges, as well as very ancient iron chisels, hammers, wedges, and trowels. The quartz-crushers are thrown down near their basins. A pile of skeletons at the Mundie ruins gives evidence of a flight or massacre; cakes of gold lying by their waists may once have been held in a belt."[1]

In Europe the Romans took up the Phœnician workings after the destruction of Carthage. During their occupation of Spain, from 210 B.C. to about 425 A.D., they busied themselves with the mining of gold, silver, and copper. Spain became the Roman Siberia, to which slaves were sent by thousands to end their days in the mines. Polybius says that 40,000 men worked the mines of New Carthage alone. From Pliny and Titus Livius we learn that 20,000 pounds' weight of gold came annually from the Iberian Peninsula. Little is said of the copper workings, though these, especially in the Rio Tinto districts, must have been enormous. The heaps of slag and cinders which, near the Rio Tinto and Tharsis mines, almost rise to the dignity of

[1] "The Romance of Modern Exploration," p. 262.

hills, have been calculated to contain upwards of 30,000,000 tons of ore and rubbish. Gonzalo Tarin, a Spanish expert, estimates that it took the labour of 10,000 slaves working for 45,000 days to amass this huge quantity of "dump"; and that during the Roman occupation over 10,000,000 tons of copper were extracted from Huelvan mines. The Romans drove miles of tunnels through the hills, and hollowed out great chambers in the ore-body. Their mining skill is suggested by the water-wheels and other devices found in the underground workings, and by the remarkable regularity of the excavations.

When Julius Cæsar invaded England in the year 55 B.C. he wrote: "They [the Britons] use brass money and iron rings of a certain weight. The provinces remote from the sea produce tin, and those upon the coast iron, but the latter in no great quantity. Their brass is imported." After their experience of Spanish mines the Romans were encouraged to seek mineral treasures in "Ultima Thule." They have left traces of their activity in many parts of the kingdom. In Cornwall they extracted tin. In Northumberland, Derbyshire, Yorkshire, Cheshire, Nottinghamshire, Shropshire, the Wye Valley, and the Forest of Dean, they mined lead. Pliny, in referring to this metal, says "It is extracted with a great labour in Spain and throughout the Gallic provinces. But in Britannia it is found in the upper stratum of the earth in such

abundance that a law has been spontaneously made, prohibiting any one from working more than a certain quantity of it." The Mendip Hills, Somersetshire, are pitted with Roman lead mines. The slag left by the Romans has been re-smelted in recent years and has yielded large quantities of metal. Copper was raised near Oswestry; gold in Caermarthenshire; iron in several counties. Rude furnaces and masses of iron slag have been found overgrown by peat or buried beneath accumulations of soil.

Roman mining in Britain reached a fairly high standard of excellence. In Cornwall there still exists an adit, or tunnel, driven from the bottom of a hill into a lode to drain off the water. The work is distinguished by the symmetry of the arch and the careful masonry of the stones which line it.

Passing to the New World, we find but few traces of distinctly ancient mining. Until the coming of Europeans, the methods of extracting ore were mostly very primitive in both North and South America. In the copper districts of Lake Superior the aborigines used only stone hammers and perhaps bags of hide to remove the metal hacked off the great lumps of it which here and there showed above the surface. In Central America tombs have been opened containing stone chisels, awls, and polishers, with which the old inhabitants of Panama attacked the gold "placers," or surface deposits, ages before the arrival of the Spaniards.

The Aztecs of Mexico and the Peruvians had con-

siderable knowledge of mining, though ignorant of the uses of iron. With bronze tools they burrowed into the hills and took out gold, silver, tin, and copper in large quantities. Of the Peruvian methods Prescott writes, "They did not attempt to penetrate into the bowels of the earth by sinking a shaft, but simply excavated a cavern in the steep sides of the mountain, or, at most, opened a horizontal vein of moderate depth. They were equally deficient in the knowledge of the best means of detaching the precious metal from the dross with which it was united, and had no idea of the virtues of quicksilver—a mineral not rare in Peru—as an amalgam to effect this decomposition. Their method of smelting the ore was by means of furnaces built in elevated and exposed situations, where they might be fanned by the strong breezes of the mountains. The subjects of the Incas, in short, with all their patient perseverance, did little more than penetrate below the crust, the outer rind, as it were, formed over those golden caverns which lie hidden in the dark depths of the Andes."[1]

Both nations managed, however, to amass much treasure for their rulers. When Cortes divided the spoils of Mexico he had to deal with gold and silver plate worth £1,417,000; while Pizarro in Peru melted down three and a half million pounds worth! It is probable that the treasure captured was but a fraction of the total; since the vanquished would

[1] "The Conquest of Peru."

have hidden many of their precious possessions as soon as they found what the Spaniards came for. Under the conquerors European methods increased the yield of the mines so greatly that Spain took the foremost place among the nations of the sixteenth century in wealth and power.

The science of mining has advanced gradually with the increase of mechanical knowledge. Until the invention of gunpowder, and in many places for a long time afterwards, the shafts and levels were driven entirely by means of picks and wedges. The labour must have been infinitely more tedious and painful than it is to-day, when, in spite of all our modern appliances, a miner's life is one of the hardest possible. As Dr. John A. Church has said:[1] "The old mines were horrible working places. The galleries were low, tortuous, so poorly supported that accidents by caving of the roof were probably frequent. They were lighted by pine knots or by lamps, made only of a clay saucer filled with ill-smelling vegetable oil or tallow, in which a bit of rush, pith, or rag, floating, served for wick; and they were without ventilation to carry off the dense smoke from these lamps and the effluvia arising from severe labour. Even after centuries of experience, when mining had become a great industry, the condition of the mines was deplorable."

One of the greatest hardships was the want of a current of fresh air to reduce the heat of the galleries

[1] *Cassier's Magazine*, March 1899.

and provide pure oxygen for the workers' lungs. In the sixteenth century rough ventilating fans were constructed — the vanes sometimes edged with feathers — to create a draught in the galleries. About the same time pumps were installed to free mines of water, a task previously only possible, and that on a very limited scale, by the raising of buckets with windlasses or on men's backs. We may suppose that gunpowder was not used below ground until methods of ventilation were fairly perfect, since its poisonous fumes would have rendered stagnant air quite unbreathable for a long time after an explosion.

The ladder still survives in many mines as the sole means of descent and ascent, involving an immense amount of extra fatigue. Steam power only was able to give quick transit, first in the "man-engine," such as is still used in Cornwall, and afterwards in the rope-hoisted cage. Steam was also harnessed to ventilating and pumping machinery, and later to that for lighting. But for explosives and steam, modern deep-mining would have been absolutely impossible. Man now sinks shafts 5000 feet down into the earth, and from the bottom burrows horizontally. He sends copious currents of air to the lowest depths; pumps out the water, if need be; and leads compressed air and electricity through a maze of pipes and wires to work machine-drills which, in combination with high explosives, relieve the miner of a large part of the toil otherwise necessary to secure the minerals.

Ancient Mining

As we shall read in future pages, the underground workers of to-day have hardships and perils to encounter, but in comparison with the surroundings of those who first explored the deep treasure-houses of Nature, theirs is a comfortable and happy lot.

CHAPTER III

THE ELDORADO OF THE GREAT WEST

The Sierra Nevada—The result of altering a mill-race—First discovery of gold in California—Booty scented by the public—Gold reaches San Francisco—Sudden rise in wages—Scenes in 'Frisco—Off to the diggings—The Mormons—The mining outfit—Scarcity of water—Disappointed hopes—"Placer" mining—Panning-out—The sluice—Racial feeling—Hardships and disease—Riotous extravagance—What the average miner got—Rough justice—Danger of wealth—Incredible selfishness—Trouble in San Francisco—The trans-continental journey—What Mark Twain saw—Rapid increase in California's population—The miner's restlessness—The sad results—Exhaustion of "placers"—Hydraulic mining—Gigantic "flumes"—How gold is washed out by the hydraulic jet—Devastating effect on the country.

PARALLEL to the coast of Upper California, at a distance inland of about 200 miles, runs the Sierra Nevada, a continuous and lofty range marked by a line of dominant peaks, many of which are over 14,000 feet high. It has an average width of about eighty miles, and its western slopes are more gentle than the eastern, which abound in precipitous declines.

From the mountains many streams hurry westwards to join a main river, called the Sacramento, flowing into the San Francisco Bay. On their way these tributaries cut through mighty deposits of gravel, which in the course of the ages have been detached from the heights and distributed along the valleys. From the latitude of San Francisco north to Oregon

the strata of the range have received a liberal salting with gold at the hands of Nature; and the water has separated huge quantities of it from its bed, to strew it in the river courses and in gulches through which streams no longer flow.

This huge auriferous belt on the Sierra's western slope is the Eldorado of the West.

One January day in 1848 a Mr. Marshall was making alterations at his saw-mill on the Americanos River, which enters the Sacramento at a point where the town of the same name now rises. The tail-race of the mill being too narrow to allow the water to run off in sufficient quantities to get full work out of the wheel, he threw the mill-wheel out of gear, and suddenly let the whole body of water behind the dam loose into the race. This operation considerably enlarged the narrow channel, and a mass of sand and gravel was carried off by the force of the current. Captain Sutter, a neighbour, thus related what followed to Dr. J. Tyrwhitt Brooks, one of the pioneer miners:[1] "Early in the morning after this took place, he was walking along the left bank of the stream, when he perceived something which he at first took for a piece of opal—a clear transparent stone, very common there—glittering on one of the spots laid bare by the sudden crumbling of the bank. He paid no attention to this: but while he was giving directions to the workmen, having observed several

[1] *Vide* "Four Months among the Gold Finders in Alta California," p. 40 foll.

out. The talk soon bred a perfect *furore*. All the workpeople struck. Out of fifty new buildings in course of construction only about half-a-dozen were not bereft of artisans; the majority of whom, together with lawyers, storekeepers, and merchants, were bitten by the fever. On many a door could be seen a paper bearing the legend, "Gone to the diggings."

Wages increased by leaps and bounds. The people who remained behind could ask their own terms. Salesmen and shopmen got 2300 to 2700 dollars a year, with board; and even boys received salaries which in the pre-mania days would have satisfied the heads of large departments. But while many houses were being deserted, fresh inhabitants poured in by sea, many having come across the Isthmus of Panama to a point where they could take ship. Up sprang a host of canvas booths to accommodate the newcomers. In the better parts of the town stupendous taverns, gambling houses, and other buildings commanded huge rents; anything up to 100,000 dollars a year. "Skirting the beach," writes an eye-witness,[1] "was a vast collection of tents, called the 'Happy Valley'—since more truly designated the 'Sickly Valley'—where filth of every description, and stagnant pools, beset one at every stride. In these tents congregated the refuse of all nations, crowded together; eight people occupying what was only space for two. Blankets, firearms, and cooking utensils were

[1] Mr. William Shaw.

the only worldly property they possessed. Scenes of depravity, sickness, and wretchedness shocked the moral sense, as much as filth and effluvia did the nerves ; and such was the state of personal insecurity that few 'citizens' slept without firearms at hand. The constant wearing of arms by such a disorderly set, amongst whom quarrels were frequent, caused many disputes to terminate disastrously ; but the unsettled state of the country, and the many desperate characters prowling about, made it necessary to be armed for self-protection—the weaker party was only sheltered from oppression by a loaded revolver, as there was no assistance to be expected from others. Steel and lead were the only arguments available for redress, and bystanders looked on unconcernedly at acts of violence; the cause of the dispute, or the justice of the punishment inflicted, being seldom inquired into."

A poor man arriving in San Francisco had small chance of comfort. Even if he possessed a fairly heavy purse, it soon lost its weight in a city where a good meal cost three dollars, even if the owner kept clear of the many gambling hells which kept open house for the allurement of "greenhorns."

In the 'fifties San Francisco was very inaccessible as compared with its position to-day at the termini of several great transcontinental lines. To get thither from the east coast the traveller had a choice between a tedious sea journey round the Horn ; a partly sea and partly land route *viâ* the Panama

Isthmus—across which a road and subsequently a railway were driven; and a land march of some 3000 miles. Nevertheless, the distant Sierras soon teemed with a population of many thousands. Most of the immigrants, at least during the first two years, came in from the coast; while a minority worked across the trackless plains, braving the hostility of the Indians and the many physical difficulties of a passage through a waterless, trackless, and arid region. Many a bloody battle was fought between the white gold-seeker and the scalp-loving Crow, Pawnee, or Sioux. Though the lighter colour eventually prevailed, the natives, well skilled in the arts of treachery and ambuscade, often murdered parties of their natural foes, and escaped with their gory trophies into the fastnesses of the mountains.

Shortly after the discovery of gold a large emigrant band of Mormons entered California across the Rockies. Without wasting time they made straight for the Americanos River, and began washing out the golden flakes and dust which permeated the bed of the stream. They did not have the valley to themselves for long, since the miners from San Francisco were now on the march to the "Mormon Diggings," as they were called after the first-comers.

The miners leaving San Francisco for the gold-fields often banded together for mutual protection and help. The perils of the journey were such as

On the way to the Yukon Goldfields. Summit of the Chilkoot Pass, with impedimenta of prospectors. April.

to render the passage of a solitary person a terribly risky business.

Before starting, the more prudent gold-seekers equipped themselves with an outfit: viz., tent, spades, mattocks; axe, blankets, hides; coffee, sugar, whisky, brandy; knives, plates, forks, pots and kettles. If funds permitted, a horse or two would be added to the list as beasts of burden, and any one who could afford it purchased a mount for his personal use.

For some days the track up country lay through an undulating, park-like region, where sycamore, oak, and cypress offered grateful shelter from the burning sun. Then the landscape changed, and bare sand-hills replaced the green vegetation. Horrible dust-storms filled the eyes and mouths of the travellers; hot winds parched their skin till it cracked; and to these discomforts were added the pangs of thirst. On one occasion a party met a straggler who offered them a flask of brandy—priceless at the "diggings"—in exchange for just half-a-pint of water. The barter was refused, because water was excessively scarce among the party; and the poor wretch learnt that the necessaries of life are after all superior to its luxuries.

Here and there they fell in with men returning from the mines, broken in hope and health, who prophesied ruin to any one who entered the diggings, and advised a retreat before it was too late. Such advice, as may be imagined, was quite unheeded,

for the prospect of finding gold appeared to blind everybody who had not yet tried his luck at the game to all considerations of possible physical collapse.

Travellers had to reckon with the Indians, ever on the alert to steal a horse or any other possession of the white invader. At night watches were set, and if the guard, overcome by the fatigues of the day, nodded at their post, an animal or two would probably be missing when daylight returned.

The strains of such a journey often let loose evil passions; and men who had started from San Francisco bound together by solemn pledges to stick to one another, would quarrel and separate, each endeavouring to be first at the diggings.

But the roughest path has an end; and at last weary eyes were gladdened by the sight of tents lining the banks of a stream. A canvas erection of unusual size indicated a "store," where Indians, Oregon trappers, with skin tanned to the consistency of a buffalo's, Spanish Dons of the old school, hatchet-faced Yankees, keen-eyed as the eagle, jostled one another as they exchanged their gold-dust for food and tools.

We may now turn our attention to the gold-saving methods employed at the Californian "placers." At first operations were confined almost entirely to the shallow or surface diggings, where the gold lay at, or just below, the surface. Not until the superficial stratum was pretty well played out was serious attention paid to the deeper

placers, which could be worked only through long tunnels and shafts.

The principal implements used for shallow working are the pick and shovel, pan, cradle or rocker, and the sluice. The pan, about twelve inches in diameter at the bottom, is of stamped iron, and much resembles the ordinary dairy milk-pan. To extract gold from the earth with which it mingles, the pan is filled with the "dirt" and taken into the water—a stream, tub, or pool, as the case may be. It is submerged, and the miner works the dirt with his hands until the lumps have crumbled; then, holding one side of the pan rather higher than the other, he gives it a peculiar circular motion which produces a rotatory current and causes the lighter portion to pass over the lip, the heavier particles remaining behind. The earthy element is thus gradually eliminated, and the pebbles are picked out by hand, until only a small residue remains, which is either pure gold, or gold mixed with a small quantity of sand. The residue is then carefully dried in an iron vessel, and the earthy dust can be blown away, leaving nothing but pure gold.

Panning is slow and laborious work, so that those who had money or skill sufficient to provide themselves with a rocker—or "gold canoe," as the Indians styled it—resorted to this less primitive method of washing. The rocker resembles a child's cradle. About six inches from the top is a drawer, with a bottom of perforated iron. Earth

is thrown by one man into the drawer and well flooded with water to break up the lumps. A second miner rocks the cradle backwards and forwards till the finer contents of the drawer fall through into the sloping tray below, on which are cross bars, called riffles, to arrest the gold.

Much more scientific than either of these simple contrivances is the "sluice," a long, slightly inclined trough, through which water flows rapidly. Its dimensions vary according to circumstances. In some cases only a single trough, ten to twelve inches deep, fifteen to twenty wide, and twelve feet long, would be used; but as each trough tapers towards its lower end, any number can easily be fitted one into the other to form a continuous sluice thousands of feet in length. The trough bottom is well provided with riffles, sometimes charged with mercury to catch the particles of gold; the more mercury being needed the finer the separation of the metal dust. Sluice washing is, if possible, carried on without interruption day and night, for weeks, even for months. Then comes the "clean-up." The gold, either "free" or amalgamated with the mercury, is carefully scraped from the riffles and washed clean in a pan. Amalgam has to be squeezed in buckskin or canvas, which allows the liquid mercury to pass, but retains the solid amalgam. This is put into a retort, and subjected to great heat until all the mercury has vaporised and been led into a condenser, where it resumes its liquid form. The gold thus obtained is

very porous, or "spongy"; and must be melted down and run into bars to be fit for sale.

In '49 and '50 the rocker and pan did most of the work. The toil was severe, in the case of the pan, which required constant stooping, while the constant immersion of the hands rapidly macerated the skin and made them very painful. The rocker saved the hands this injury, and, by employing several sets of muscles, enabled the miner to keep on working without much physical discomfort. By a rule of the diggings, when a party operated a cradle, a nugget weighing over half-an-ounce was considered to be the private property of the person who found it, and was not added to the common fund of metal.

Since several nationalities occupied the diggings race-feeling became acute. The Americans, who predominated numerically, showed their teeth to the "coloured" miners, and, if their property were worth the trouble, often drove them away. These ejectments sometimes resulted in serious fighting, as the injured party was always ready to resort to stealthy retaliation under cover of night.

Nor was there much love lost between the white gangs. At the Mormon diggings a quarrel broke out over a sluice which damaged the claims lower down the valley. The sluice owners refused compensation to the injured diggers, who, accordingly, raided the aggressors. Knives, picks, rifles and pistols were freely used. Heads were smashed in, limbs lopped, bullets flew; and in a few minutes

the ground had all the appearance of a miniature battle-field.

No truthful picture of these early camps can, unfortunately, be a pleasant one. Even in the hot season the nightly dews were so heavy that blankets would be saturated by the morning. In the rainy season a deluge fell, against which the frail erections of earth and canvas afforded little shelter. Owing to exposure, hard work, and poor food, disease stalked in many shapes among the miners. The most prevalent complaints were dysentery, fever, and ague, for which little help could be procured, since the few doctors present charged exorbitant fees, and medicine was practically non-existent. Every now and then a poor wretch, mad in the delirium of fever, would rush frantically from his tent and attack anybody who came in his way. "One morning," writes Mr. Shaw, "I took a stroll round the tents ; a most ominous silence prevailed ; of the busy crowds not one was to be seen at work ; all was as still as an hospital. We had not been the only sufferers ; sickness universally prevailed, seemingly as infectious as the plague. In every tent lay sufferers in various stages of disease ; out of two hundred, at least twenty had died, and not more than sixty were able to move ; those convalescent would be seen gathered together in the stores. Those who were too ill to frequent scenes of dissipation excited my compassion ; they lay huddled together in tents, moaning and cursing, many of

them dying, with no one to attend to their spiritual or bodily wants; and I cannot but think that many died from sheer starvation, or mere want of attendance."

Side by side with this dreadful suffering existed riotous extravagance. The few fortunate diggers gambled deeply, staking their bags of gold dust against the turn of the cards. Being men of no education, they imagined that lavish expenditure of their easily-won wealth would raise them in the estimation of their less fortunate fellows. Accordingly, they might be seen seated on rough benches, breaking off the necks of champagne bottles, to quench the thirst arising from a diet of sardines, lobsters, and other luxuries—all, of course, purchased at famine prices. Under the circumstances it is not surprising that the store-keepers, who never did a hand's turn of gold-washing, made the largest fortunes. A spade which cost originally one dollar might fetch thirty at the diggings. Thirty-four pounds of biscuit, salt beef, beans, and flour cost fifty dollars; and at one time, when scurvy prevailed, and fresh vegetables had run out, the lucky importer of some potatoes sold them at a dollar apiece, to be eaten raw, like apples!

With respect to the richness of the diggings, many stories have been told which greatly exaggerate the reality. In a few instances immense finds were undoubtedly made by pioneers, but the average product of a hard day's work would not exceed fifteen to eighteen

dollars. Of the thousands who visited the "placers" only about one-third became resident diggers; and higher up in the Sierras, beyond what was afterwards recognised to be the limit of the gold-bearing belt, the early miner made long and wearisome journeys over the crests of snowy mountains, and even into the arid deserts beyond, without ever seeing the colour of gold.

Thousands worked like slaves, and won their ounce or so daily from the river deposits; but living was so expensive that these returns only sufficed to keep body and soul together. Many diggers, hoping for richer finds, stayed on until their small stores of dust had vanished into the store or saloon, and it became absolutely necessary to retire, beaten, from the struggle.

Though robbery and violence were only too prevalent at the diggings, a very rough justice awaited anybody caught committing a theft. The first dozen men who came up constituted themselves into an informal jury, and passed summary sentence: the loss of one or both ears, with hanging in reserve for serious offences. Sometimes the Indians made a night raid, massacred the occupants of outlying tents, and decamped with their food, clothes, and other possessions. A band of avengers having been collected, they went on the track of the depredators, guided by some old trapper well versed in backwoods craft. As often as not the Indians were run to earth, and treated with a severity that instilled

into them so wholesome a dread of the white man and his "thunderstick," that the natives in certain districts ceased to raid, and entered the service of their former enemies.

Even if a man amassed wealth it was apt to be a source of great personal danger to him. He was watched and followed about on the chance of an opportunity occurring of putting him quietly out of the way. Bands of desperadoes roamed the country, ready to swoop down on the lucky miner returning with his hoard to San Francisco. Dr. Tyrwhitt tells of a big American who had accumulated a very large amount of gold, and who suspected that every visitor to his tent was on robbery bent, and acting as a spy. Any harmless person who looked in accordingly received notice to quit in a few seconds if he did not wish to receive a dose of lead from the ever ready rifle or revolver.

The gold-fever bred a selfishness that sounds almost incredible. Help was refused to the dying. When death at last released the poor sufferer, his living comrades often refused to cease work for a few 7
minutes to give the corpse burial, preferring to let it become the prey of the coyotes. A visitor to the mines had good reason for arguing that when gold comes in at the door all human sympathy flies out of the window.

After the lapse of a few months serious trouble brewed in San Francisco. While labour was still scarce wages reached fabulous figures; but with a

great influx of broken miners these prices could no longer be maintained, though the cost of provisions and other necessaries showed no signs of diminishing. Discontent prevailed among the lower classes. Nightly meetings took place, at which agitators made furious tirades against employers and those "foreigners" who ventured to sell their labour at cheaper rates than the mob approved of—*i.e.* for less than ten dollars a day. Poor fellows suspected of being "blacklegs" were taken to a high cliff, called the "Tarpeian Rock," and hurled on to the beach below, used as a common burying-ground, where the sand brought in by the rising tide performed the office of sexton. Yet, in spite of all this inhumanity and villainy, the town was rapidly increasing, and in the face of labour troubles lofty warehouses rose to the very edge of the hills behind the towns. Fine hotels, huge business houses, and public offices were erected, and eagerly rented by far-seeing people whose sagacity told them that the gold-rush would be followed by occupations more steadily prosperous than "placer" mining.

For five years the "rush" continued. Men poured in from all sides. The terrible trans-continental journey was undertaken by thousands of immigrants who started from St. Louis or Omaha on the Missouri, pushed along the Platte River, crossed the Rockies, encountered the horrors of the Great Salt Lake Desert, and, after a final struggle with the Sierra Nevada, dropped down into the Land of Promise, their

numbers sadly thinned by wounds, accidents, disease, hunger, and thirst. Mark Twain, writing of this route, and the Great Desert in particular, said:[1] "It was a dreary pull, and a long and thirsty one, for we had no water. From one extremity of this desert to the other, the road was white with the bones of oxen and horses. It would hardly be an exaggeration to say that we could have walked the forty miles and set our feet on a bone at every step! The desert was one prodigious graveyard. And the log-chains, waggon-trees, and rotting wrecks of vehicles were almost as thick as the bones. I think we saw log-chains enough rusting there in the desert to reach across any State in the Union. Do not these relics suggest something of an idea of the fearful suffering and privation the early immigrants to California endured?"

It is impossible to say how many miners were actually at work in California at the time of the greatest excitement, but 50,000 is the figure suggested for 1850. In 1852 and 1853 this number had probably doubled; and as the new-comers found the rich deposits of surface gold ready to hand the total output of these years marked the highest level of the Californian output,—some 65 million dollars' worth per annum. Memorable among the richest "strikes" of those days are those of the Stanislaus, Americanos, Yuba, and Feather Rivers, where the fortunate owners washed out from *one to five thousand dollars a day!*

[1] "Roughing it," chapter xx.

But such spots as these were very limited in area, like the rich "pockets" found in the mountains, where gold had accumulated most amazingly. One of the pockets yielded 60,000 dollars in two weeks; another just double that amount in three months; while smaller deposits, laid bare in several instances by rooting hogs, panned out 5000 dollars and upwards.

As soon as the richest bars and gulches had been worked over, a spirit of restlessness affected the miners, who were, as Mark Twain says, "no simpering, dainty, kid-gloved weaklings, but stalwart, dauntless young braves, brimful of push and energy, and royally endowed with every attribute that goes to make up a peerless and magnificent manhood—the very pick of the world's glorious ones." Mr. Twain is evidently here referring only to the more respectable part of the population, as the immigrants certainly contained a high percentage of thoroughgoing scoundrels, who, if not villains to begin with, rapidly developed into such under the deteriorating influences of gold-mining. Yet in his pages, and in those of Mr. Bret Harte, we are able to detect the kindliness that often concealed itself under a rough and forbidding exterior. The man who was ready to draw his "gun" on little provocation, could also lend a helping hand to a mate in time of need.

These folk, wrought to a pitch of nervous frenzy by the myriad reports flying about, were only too easily induced to leave a locality of moderate wealth,

and to plunge into the unknown beyond the mountains. After months of fruitless searching for the advertised "inexhaustible focus of gold," they would return—those who had not succumbed to privation—poverty-stricken and ragged, to find the claims they had left already occupied by fresh arrivals. A great "rush" of this description took place in 1855, to the Kern River, 250 miles south of San Francisco. Three years later 20,000 men picked up their traps and stampeded to the Fraser River, denuding California of a large proportion of her workers. The sufferings of this misguided mob were terrible; their success very moderate.

By 1855 the "shallow placers" had been almost exhausted. The pan and rocker no longer brought out enough gold to render their use profitable. There remained, however, the deeper placers and the "lode" gold, embedded in a quartz matrix. So, while a thousand little mushroom mining cities, deserted by their busy population, crumbled into ruins amid the deathly silence of the valleys, a hundred more rose elsewhere, occupied by men bent on continuing the search with a more scientific equipment, and a different organisation of labour.

We will therefore turn our attention to—

Hydraulic Mining,

with which is connected the second chapter of Californian metallurgical history.

In some of the valleys the prehistoric glaciers

accumulated beds of gold-bearing gravel to a thickness probably unparalleled in the rest of North America. Inasmuch as the greater part of the gold sinks to the bottom of a bed, it can be reached only by shafts and tunnels, unless the whole mass is in some manner disintegrated, washed, and carried off by water.

If you have ever watched a fire-engine at work you must have been impressed by the force with which the water jet strikes an object against which it is directed. Imagine such a jet turned on to a bank of crumbling gravel, and you have the essential idea of hydraulic mining.

In order to carry out such operations successfully an abundant supply of water under very high pressure is needed. To this end special companies were formed in California to bring water long distances from mountain lakes or rivers, through ditches, troughs, or pipes, to the scene of operations. As the channel is built on a much gentler gradient than that of the valley along the sides of which it runs, by the time it reaches the mine it may have a "head" of some hundreds of feet. From the end of the channel the water is led down through pipes of decreasing diameter to nozzles, three to six inches in diameter, which fire it against the gravel bank with enormous power. An expert has stated that a strong man could not possibly strike a crow-bar through a six-inch jet of water coming out under a 300-foot "head"! This is extraordinary, though a fact; and

men and animals have been killed by the jets at a distance of 200 feet or more from the nozzle!

The "flume" companies expended huge sums on this kind of work in the 'sixties. In Nevada County is the Grand Trunk line of the Eureka Lake and Yuba Canal Company, running from four small lakes near the summit of the Sierra to North San Juan, sixty-five miles away. The Eureka lake supplies most of the water. A granite dam two hundred and fifty feet long and seventy feet high was built across the valley to impound 930 million cubic feet of water. The main trunk carrying the water to the mines is eight feet wide by three-and-a-half deep, and has a fall of about one foot in a hundred.

Not far away runs the South Yuba Canal, sixteen miles of which cost about 600,000 dollars. It passes through several tunnels. "One of these," writes Mr. T. F. Cronise,[1] "sixty feet in length, cost 6000 dollars; another, 3800 feet long, having cost 112,000 dollars. The flume, seven miles long, runs for one and a-half miles through a gallery worked into the side of a precipice of solid rock one hundred feet high—the cliff being so impending that the workmen had to be let down from the top to commence drilling and blasting, an expedient not at all uncommon in the construction of these works in other parts of the state. . . . From the main trunk ditch-branches ramify, carrying water over an immense tract of country, supplying a vast number of mills, hydraulic

[1] "The Natural Wealth of California."

and sluice claims. This company has thrown dams across the outlets of four lakes situated near the summit of the Sierra, using them as reserves for supplying their canals in the dry season. One of these dams, constructed of solid masonry, 42 feet high and 1150 feet long, has increased the volume of Meadow Lake more than tenfold — this lake, formerly a mere pond, now being, when full, more than a mile and a quarter long by half a mile wide."

This company spent 1,130,000 dollars on their works, but in twelve years netted 1,400,000 dollars in receipts.

Placer County boasts the Auburn and Bear River Canal, 290 miles long, which cost 670,000 dollars; Amador County has a 400,000 dollar ditch of 66 miles; Calaveras County, a 50 miles ditch, which cost 350,000 dollars; and in Tuolomne County runs the 40-mile Big Oak Flat, and the 35-mile County Water Company's aqueduct, costing 600,000 dollars and 550,000 dollars respectively. Since 1870 even larger pipe lines have been laid; in most cases with a very good result to the owners and users.

Having secured water, the hydraulic miner has done only part of the work preparatory to an attack on the gravel-bed. The whole of this must be detached, broken up, robbed of its gold, and carried right away, without any cessation of labour.

When the mining ground has been selected, a tunnel is driven into it from a neighbouring ravine

through the rock, approaching the gravel on a steady up grade of about one in eight. The tunnel of a large working measures 7 feet in height and as many in width; its length ranges from a few hundred feet to several miles. In the latter case it becomes a big engineering feat, accomplished only by the help of scientific calculations and proper rock-boring tools, and necessitates a heavy capital outlay. This will account for such tasks not figuring in earlier Californian mining days.

The upper part of the tunnel is so driven that its end lies fifty to a hundred feet below the gravel-bed. A shaft is then sunk to meet it, and the "way out" is clear. All along the bottom of the tunnel and far down the ravine into which it empties is laid a large sluice, 2½ feet wide, and of sufficient height to handle all the water that the hydraulic pipes can deliver. Between the blocks the miners pour tons of mercury to catch and absorb the fine particles of gold.

The jet is now directed against the earth round the shaft's mouth, which, under the continuous action of this enormous mechanical force, quickly crumbles away, and falls into the shaft. Even big boulders weighing half a ton or more are shifted, and make the plunge, splintering themselves and anything on which they alight, thus acting as an automatic crushing machine. A deep trench is gradually opened along the bed, and then the walls receive attention. If very lofty, they are worked in two

stages, the upper crumbling easily, while the lower may have to be blasted with explosives before the water can affect it. Tunnels are driven horizontally through it, and from them shafts right and left to receive the explosive, which breaks off huge masses of the conglomerate, and disintegrates them sufficiently to be affected by the jet.

Every month or so comes the "clean-up." In some cases the returns are very heavy, averaging a thousand dollars and upwards per diem. Clean-ups of one hundred thousand dollars are recorded. And the metal is won comparatively cheaply, each cubic yard treated costing but one-hundredth of the labour-bill for panning. Of course, in hydraulic as in other forms of gold-getting, there are failures, which are ruinous in proportion to the outlay on preliminary engineering.

The effect of hydraulicing on the country is, from the scenic point of view, appalling. "Tornado, flood, earthquake, and volcano combined could hardly make greater havoc, spread wider ruin and wreck, than are to be seen everywhere in the track of the larger gold-washing operations. None of the interior streams of California, though naturally pure as crystal, escape the change to a thick yellow mud, from this cause, early in their progress from the hills. The Sacramento is worse than the Missouri. Many of the streams are turned out of their original channels, either directly for mining purposes, or in consequence of the great masses

Hydraulic Gold Mining. A bank of gold-bearing gravel is washed down by a jet of very high-pressure water directed on it from a nozzle. The washed-down gravel is carried by the water through sluices, which

of soil and gravel that come down from the gold-washings above. Thousands of acres of fine land along their banks are ruined for ever by the deposits of this character. A farmer may have his whole estate turned into a barren waste by a flood of sand and gravel from some hydraulic mining up stream; more, if a fine orchard or garden stands in the way of the working of a rich gulch or bank, orchard or garden must go. Then the torn-out, dug-out, washed to pieces and then washed over side-hills, masses that have been or are being subjected to the hydraulics of the miners, are the very devil's chaos indeed. The country is full of them among the mining districts of the Sierra Nevada, and they are truly a terrible blot upon the face of Nature." This picture is from the pen of an author[1] who traversed the country in 1868, and what he saw then can be seen to-day on a still larger scale. Probably in no part of the world has water been so extensively employed to maltreat Nature's arrangements as it has in California, the home of hydraulic mining.

Of the quartz mines nothing need be said here—since the methods of separating gold from rock will be fully treated in a following chapter—except to refer to the huge amounts of metal that the lodes of the Sierra have yielded; especially the Great Quartz Vein or "Mother Lode," which has been traced for 80 miles, and has been worked to an enormous depth.

[1] Mr. Samuel Bowles, "Our New West."

CHAPTER IV

THE GOLD-FIELDS OF THE ANTIPODES

First discovery of gold in Australia — A convict's hard luck — Early discoveries hushed up — Hargraves finds the New South Wales deposits—The "rush"—Melbourne folk alarmed—Gold found in Victoria—Huge nugget found at Meroo Creek—Its effect on the colony — Victorian gold—Wonderful "pocket" struck — Overcrowding of Melbourne — "Canvas Town" — Rapid growth of Melbourne — Ill-feeling aroused by mining fees—Ballarat riot—Gold-field extravagance—Curious plight of South Australia—Special measures for gold-transport—The great nuggets of Australia.

A CONVICT working in New South Wales during the 'thirties produced one day a small lump of gold which he professed to have found in the earth; but being unable to point out the spot to the people, he was haled before a magistrate and awarded one hundred and fifty lashes as the penalty of having *melted down a gold watch.* The magistrate apparently did not reason that a man who had stolen a watch would hardly be fool enough to publicly exhibit the gold of its case as metal discovered in its natural state. But those were days when suspicion and punishment walked hand-in-hand among the "ticket-of-leaves."

Thus inauspiciously began the discovery of gold in Australia. In 1839 Count Strzelecki reported to Sir G. Gipps, the then Governor of New South Wales, that in the Vale of Clwydd he had found a deposit of auriferous sulphuret of iron, containing an

insufficient proportion of the precious metal to repay the cost of extraction. Two years later Dr. W. B. Clarke, a Sydney resident, detected gold in the vicinity of the New South Wales capital; but, like the Count, he was asked by the Governor to keep the find secret on account of the difficulty of maintaining order among 45,000 convicts that would ensue were the news spread abroad.

At this time Australians were occupied with the pursuits of sheep and cattle raising. They knew nothing of gold-fields, for the Californian treasures had not yet come to light. When, therefore, a shepherd now and then walked into a town with a few ounces of gold which he had laboriously picked out of the rocks, he was regarded in much the same light as the unfortunate convict, and set down as a robber. The better educated colonists, who owned large sheep-runs, little knew that, as they went their rounds, they were literally treading on gold. Eight years before the actual discovery of gold in 1851, a Mr. H. Anderson, while walking over his sheep-station at Ballarat with a neighbour, noticed a small piece of shining white quartz streaked with a glittering yellow substance. "Here's gold!" he cried, handing the lump to his companion, who said, "Tut-tut, man, golden nonsense!" and made Mr. Anderson so mistrustful of his own judgment that he heaved the quartz at a pair of laughing jackasses near by, and thought no more of the matter.

The scientific statements made with regard to the

existence of gold by Count Strzelecki, Dr. Clarke, and Sir Roderick Murchison during the 'forties might have produced no results for many a long day, had not gold been discovered thousands of miles away in California, whither a large part of the Australian population had migrated. Among the gold-seekers was a Mr. E. H. Hargraves, who noticed the resemblance between the geological formation of the Californian deposits and certain districts with which he was acquainted in Australia. In 1850 he returned home to prove whether the pickaxe and cradle could not be used with good effect in the Antipodes. Working at Summerhill Creek, near Bathurst, in February 1851, he discovered gold, and applied to the authorities for a reward in compensation for the hardships and expenses which he had had to meet. The Government, only too anxious to check the emigration to California, offered him a handsome sum if he would show the gold-bearing locality; and on his referring them to the Lewis Ponds, Summerhill, and to the Macquarie River, a sum of money was given him, which two years later was increased to £10,000 and a pension.

As in California, the first scent of a gold-field was the signal for a "rush." From Sydney a mob of men, women, and children trooped through the Blue Mountains, leaving whole streets deserted, to be bought up by foreseeing speculators, who in a few months got their money back tenfold. Sydney became a second San Francisco, with the same tremendous rise of prices for both labour and the

necessaries of life. Servants vanished into the back country. Government salaries were doubled to keep the various staffs from unavoidable debt and insolvency. In short, only a few persons remained behind, and those few had to be well paid.

So great was the emigration from Victoria to New South Wales that the Melbourne authorities became alarmed. Something must be done to check the draining away of all labour from the colony. A reward was offered to any one who should find gold within 200 miles of the capital. People soon came to claim the money. Gold had been discovered at the Plenty River, on the Yarra-Yarra, in the Pyrenees Range, and finally in August 1851 at Ballarat.

Melbourne and Geelong were at once overtaken by the fate of Sydney in an aggravated form. They became like deserted villages. Geelong was so stripped of its males that women crowded to the doors to view any stray man who might happen to pass through; the case of California exactly reversed! *There* men paid heavily in gold dust for the privilege of a peep at a member of the gentler sex through the cracks of a shanty. In four months the population of Geelong sank from 8291 to 2850 souls!

This state of things existed only for a short time, as emigrants from China, Tasmania, South Australia, and Europe soon began to pour into Melbourne at the rate of 2000 a week. Of these immigrants a large proportion were very undesirable, being ex-convicts from Tasmania, men returned from Cali-

fornia, and the scum of adjacent colonies. Disorder grew rife at the gold-fields, where a wild forest, "honeycombed with hundreds of thousands of ready-made graves," tempted the villain who envied a lucky digger to hurl him, wounded to death, into the hole from which he had scooped a fortune.

Ballarat, Bendigo, or Sandhurst, and Mount Alexander were the great foci of attraction. The terrible roads leading to these diggings turned into dust or mud beneath the tramp of tens of thousands of people, all on treasure-hunting bent. Accounts of huge nuggets unearthed from time to time kept the excitement at fever pitch. Hungry crowds settled like locusts on claims, and without waiting, in many cases, to obtain a licence, began digging for dear life, aided by the rocker or pan. Fortunes were made quickly, as Australia, and particularly Ballarat, is notable for the coarseness of its gold, which seems in this continent to have largely escaped the grinding to powder so noticeable in California. One man, who had saved up £100, invested the sum in as many acres of land, which two years later he sold to the diggers for £120,000! and there are plenty of instances recorded in which a single stroke of the pickaxe or blow of the spade enriched the worker for life.

One of the most remarkable nuggets came to light very early in 1851, at Meroo Creek, New South Wales. An Australian black, employed as a shepherd by Dr. Kerr, amused himself with gold-seeking while tending the sheep. He happened to see a speck of

some substance glittering on the surface of a quartz boulder, and chipped off a piece with his tomahawk, and there, embedded in the rock, lay a mass of gold which, when placed on the scales, weighed 102 lbs. 9 oz.—a value of over £4000 sterling!

The arrival of this nugget in Bathurst—the centre of the New South Wales industry—produced a *furore* which has been thus described by a local newspaper: "Bathurst is mad again. The delirium of golden fever has returned with increased intensity. Men meet together, stare stupidly at one another, talk incoherent nonsense, and wonder what will happen next. Since the affair was blazoned to the world several gentlemen of our acquaintance have shown undoubted symptoms of temporary insanity. Should the effect be at all proportionate in Sydney to its population, the inmates of Bedlam Point may be fairly reckoned as an integral part of the population."

Victoria has contributed by far the largest proportion of gold found in Australia. The diggers got from the alluvial workings no less than 2,738,404 oz. in 1852, and 3,150,021 oz. during the following year. To quote totals, between 1851 and 1895, Victoria was responsible for 60,155,047 oz.; New South Wales for 11,421,544 oz.; while Queensland, which only entered into serious competition as late as 1860, came in a good third with 10,604,031 oz. For the first two colonies 1851 and 1852 were the golden years, since they witnessed the working over of the rich alluvial deposits. Probably the best

record for washing comes from Mount Alexander. A party of five men had sunk six holes to depths ranging from thirty to sixty feet, without success; and they were so disheartened that they determined to give up after one more attempt. Before the seventh hole was three yards deep they "struck it rich," with a vengeance. In eight hours 120 lbs. troy weight of virgin gold was amassed, giving the lucky men £5000 to divide between them!

Such "strikes" were, of course, the exception; and October 1851 saw many folk returning disgusted to Melbourne; people who were unfit for the business,—who had tried their hands, and found that, instead of getting gold easily by merely scratching the surface, they must work hard for it, experiencing meanwhile much hardship and privation. Yet even their dismal accounts did little to stem the tide of immigration. Melbourne could not house all the new-comers who poured in by every boat. Hotels and lodging-houses overflowed. A city of tents—aptly named Canvas Town—rose on the south side of the Yarra-Yarra. "The scenes in Canvas Town were such as to jar upon the feelings of even the unrefined; and in that huddled assemblage there were many delicate and sensitive persons plunged by circumstances into a vortex which the master of the tent or hut had not anticipated. For the water-police, and the female immigrants who arrived under contract, hulks were secured in the bay."[1]

[1] G. W. Rusden, "History of Australia."

The hardships of this mode of life soon rendered it imperative to provide decent shelter for those who needed a refuge. Public and private subscriptions were raised to build an "Institution for Homeless Immigrants." The buildings, though rough, were a cleanly contrast to the disgusting confusion of Canvas Town, and were gladly used by nearly 8000 people in one year.

All this movement of population had lasting effects. Before twelve months had passed, Melbourne had doubled her numbers; in a decade she rose from a small town of about 25,000 souls to a large city of 190,000 inhabitants. Land which before the "rush" cost £68 per acre changed hands, thirty years later, at £80,000; and to-day is scarcely purchasable. A writer speaking of the 1857 Melbourne says: "Only three short years ago, this undulating surface (North Melbourne) was covered with grass, and dotted over with gum trees. The traveller, as he sallied forth to the bush, in those days gone by, would turn his nag when at the highest spot, to take a last view of the thriving capital of Victoria and the bright blue water beyond, where some considerable shipping already well attested the progress of a flourishing young colony. Since then, however, all had been changed into a wild and tumultuous development. The waters of Hobson's Bay were scarcely visible beneath a forest of five or six hundred vessels. The grassy glades of North Melbourne were now a hard and dusty surface, cut up everywhere with roads,

and disturbed with the incessant noise of the traffic to the interior." [1]

No country has been more opened up by its gold industry than has Australia. Gold brought settlers, who, after the first rushes, turned from precarious metal-seeking to more monotonous, but at the same time more certainly productive pursuits. Immense sums were spent on roads, railways, and other public works, which dotted the country over with large towns distinguished by their fine buildings, streets, parks, gardens, and reservoirs. The very areas on which a solitary shepherd earned a scanty meal by tending vagrant flocks, and where the emu stalked, or the kangaroo listened for the approach of an enemy, are now busy centres of industry, whose history opens with the word "Gold," but now records the advance of many-headed Industry.

An unfortunate feature of the early mining days was the ill-feeling aroused by the collection of digging fees. The goldfields swarmed with people only too ready to applaud the fiery eloquence of the professional agitator, devoted to the breeding of quarrels between the miner and the Government Goldfields Police. Many men refused to take out licences; others grumbled at the amounts which they were called upon to pay; and so acute became the excitement that in 1854 Ballarat won notoriety as the scene of a serious armed collision. On the 6th October a miner named James Scobie was killed in

[1] William Westgarth, "Victoria and the Australian Gold Mines."

a scuffle; and public suspicion fastened itself on one Bentley, an ex-convict from Tasmania, who kept a disreputable public-house called the Eureka Hotel. A mob burnt his house, and would have lynched the proprietor had not the police stepped in and rescued him, to be afterwards tried and sentenced to three years' penal servitude. Three persons, who had been arrested on the charge of burning the Eureka Hotel, received much lighter punishments; but the Ballarat people, considering the sentence unjust, demanded their release. On this being refused, the agitators got to work and spread sedition, which terminated in a conflict between the mob and the military forces under Captain Thomas. Several prisoners were taken by the soldiers. A mass meeting unanimously chose an Irishman, Peter Lalor, as the popular chief; and on the 30th November all work was suspended preparatory to a second attack on the Government forces. The rioters fired into the camp. Three days later Captain Thomas took the offensive, carried the Eureka stockade, behind which the rebels had entrenched themselves, and made 125 prisoners, besides killing a few dozen of the defenders. The prisoners were despatched to Melbourne for trial; but instead of being awarded the penalties they so richly deserved they were pronounced "not guilty" by the twelve "good men and true," who saw in their conduct not an act of treason but the deeds of heroes. So low had law and order fallen in Victoria!

Goldfield history, like other history, repeats itself. Melbourne and Sydney were formidable rivals to San Francisco and the inland diggings in their scenes of extravagance. Though some miners quietly amassed wealth, the majority of the lower class acted up to the saying "Easy come, easy go." Mr. Rusden in his interesting volumes gives us a vivid sketch of the Australian spendthrift. "Fortunate gold scrapers flung their money broadcast in scenes of luxury and debauchery. Stories were told that many of them scorned to take change from a barber when tossing him a pound sterling; that a roughly dressed man called a cab which he required for the day; that when the driver replied that the man could not have it unless for more than he would like to pay—seven pounds—the *novus homo* threw him ten pounds, and told him to light his pipe with the difference; and that in the very drunkenness of enjoyment of their wealth many diggers lit their pipes with bank notes."[1] The shopkeepers did a roaring trade, especially with men about to be married, whose one ambition was to deck their brides in the most expensive silks, satins, and laces that money could buy. The more civilised criticism, "That is very dear," gave place to the complaint, "Haven't you anything dearer than *that?*" and the shopman was, of course, equal to the occasion. One of the most peculiar features of the Australian gold-rush—the strenuous efforts made by the different

[1] "History of Australia," ii. 543.

colonies to keep their population at home — has already been hinted at. Adelaide, the capital of South Australia, was deserted by thousands who in 1851 started for the Victorian diggings. Houses were abandoned, property became unsaleable, and business of all kinds was utterly strangled. As the emigrants carried with them all the cash they could raise, the banks, drained of gold, had to contract their circulation. And when some miners returned with 50,000 pounds' worth of the metal, they found themselves in the extraordinary plight of being unable to sell it, because there was no money available for its purchase! The Government, to cut the Gordian knot, authorised the issue of notes against the ingots, at the rate of seventy-one shillings to the ounce, the notes to be legal tender; and in the following year permission was obtained from England to coin gold tokens of five pounds, two pounds, one pound, and ten shillings respectively. Paper money then decreased, while credit and confidence were at once restored.

To facilitate the return of the population, and to ensure the influx of goldw on by South Australians into their own colony, the authorities cut a road through the "scrub" for a hundred miles, and organised a system of convoys to escort gold from Victoria to South Australia. Crowds of emigrants willingly paid the two per cent. charge made for transport. The first convoy returned with 6000, the second with 19,235, the third with 28,206 ounces; so that this colony, which in forty-five years mined

only half a million ounces from her own territory, quickly amassed wealth which, when the rush was over, led to a rapid development of the country.

Australia is as rich in "lode" gold as in "free" gold. The quartz of the mountains has yielded very remarkable returns ever since the miners overcame their antipathy to improved machinery. Occasional veins carried so much metal that the use of a mere hand hammer proved remunerative. The Mount Lyell lodes contained from fifteen to twenty ounces to the ton of rock. The quartz quarried on the surface was not, at first, sent to mills to be crushed. Only fragments from which gold peeped received attention; and even after mills were erected the methods of treatment were so imperfect that only the richest quartz yielded a profit. But with improved processes as much as £4000 a week became quite ordinary earnings for a well-situated mill.

Australian gold-mining owes so much of its romance to the large nuggets which, especially in Victoria, brought sudden fortune to some miners, that a page or two will be devoted to these interesting masses of metal.

The formation of nuggets has been explained in various ways. Some authorities suppose that they have *grown* in the alluvium, and have been gradually increased by deposits of metal from the chemically charged water which for ages percolated the stratum. Others are unwilling to accept this theory; preferring to believe that nuggets are the result of fusion. The problem has not yet received a definite solution. It

is certain, however, that Australia's nuggets are never likely to be surpassed in size. Appended is a list of the largest specimens, the date and place of their discoveries, and their respective weights[1]:—

Nugget.	Date of Discovery.	Place.	Weight in Oz.
1. "The Welcome Stranger"	Feb. 5, 1869	Dunolly, Victoria	2268
2. "Welcome Nugget" ...	June 15, 1858	Ballarat	2217
3. "Blanche Barkly" ...	August 27, 1857	Kingower, Victoria	1741
4.	Jan. 31, 1857	Ballarat	1619
5.	1857	Dunolly	1363
6.	Nov. 1, 1858	Burradong, N.S.W.	1286
7.	July 1851	Bathurst	1272
8.	Sept. 8, 1854	Ballarat	1177
9.	Jan. 20, 1853	,,	1117
10.	June 1855	Maryborough	1034
11.	Jan. 22, 1853	Ballarat	1011
12. Heron Nugget...	March 29, 1855	Mt. Alexander	1008
13.	August 1860	Ballarat	834
14.	March 1857	Kingower, Victoria	810
15.	1860	,, ,,	805
16.	February 1861	,, ,,	782
17.	Oct. 22, 1856	Daisy Hill, Victoria	715
18.	May 1856	Taradale, Victoria	648
19.	May 1858	,, ,,	648
20.	Oct. 22, 1855	McIvor, Victoria	645
21.	Feb. 1, 1854	Ballarat	625
22.	April 1860	Castlemaine, Victoria	600
23.	October 1852	Bendigo	573
24.	March 6, 1855	Ballarat	571
25. "Nil Desperandum" ...	November 1857	,,	540
26.	Jan. 15, 1858	Maryborough	537
27.	1856	Taradale, Victoria	524
28.	March 1855	Ballarat	480
29.	1853	,,	371
30.	February 1853	,,	368
31.	1851	Bathurst	366
32. "Dascombe"	January 1852	Bendigo	338
33.	1854	,,	338
34.	1860	Castlemaine	304
35.	1852	Bendigo	288
36.	May 1860	Kingower	230

[1] Compiled from a list made by Mr. William Birkmyre.

It is unnecessary to describe life in the goldfields, because what has already been said of the Californian diggings applies in a large degree to their Australian counterparts. The parallel is continued into the later history of the two countries; for a large proportion of those people who came to seek gold remained to take up sheep farming and agriculture, on which the real prosperity of both Eldorados ultimately rests.

CHAPTER V

WESTRALIA

Sterile character of West Australia—Gold at Coolgardie—A lucky find—Another lucky find—The luck of "Hannan's"—The Westralian fields—Coolgardie—Wind and Dust—Want of Water—"Dry-blowing"—"Hannan's Brownhill" and "Great Boulder"—The Coolgardie Water Supply—A pipe 328 miles long—Description of the pipe line—Effect of Gold discoveries on Australia.

RAPID as has been the development of Eastern Australia since the first discovery of gold, an even more remarkable rate of progress is transforming the—till comparatively lately—waste expanses of the most western colony. At the time when diggers first swarmed into New South Wales and Victoria, West Australia was a mere No Man's Land, uninhabited except by aborigines and a handful of convicts; and probably only a very few people ever suspected that among the sandhills lay treasure which, thirty-six years later, should open for Australia a second era of gold-mining.

The Kimberley field, in the most northerly part of the colony, was located in 1882, and "proclaimed" in 1886. But it was not till May or June of 1892 that Messrs. Bayley and Ford, starting from Southern Cross, set out on their memorable journey which resulted in the discovery of the Coolgardie goldfield, where they obtained 2000 ounces by

merely smashing up the quartz with rude implements. Though their search was deliberate, the actual find was, as so often happens in the history of mining, a matter of pure accident. Bayley had long prospected without success, and was returning to Perth, the capital, very much "down in the mouth," when the lucky moment arrived. His horse became restless in the night, and began to kick and plunge so vigorously that Bayley went out to coax the animal into quietude. Whilst on his way he stumbled over what he at first thought to be a stone, but which proved on examination to be a huge mass of pure gold! A claim was at once pegged out, and in four weeks £10,000 had been realised. This claim stands near the centre of the town which, after the inevitable "rush," sprang up like a mushroom and was christened Coolgardie, a name familiar to the ears of many people who take little interest in mining affairs.

The Pilbarra Goldfields, half-way up the west coast, owe their origin to an equally trivial incident. "It appears," says Mr. A. G. Charleton, in *The Engineering Magazine*, "that a discerning youth of tender years picked up a stone to throw at a cow (some say a crow), and, noticing that it contained gold, reported the fact to the 'Warden.' This gentleman was so excited at the news that he flashed the intelligence by wire to the then Governor of the Colony, informing him that a lad had picked up a stone, to throw it at a crow—but forgetting to add

that he had seen gold in it! The Governor, much surprised, but moved with curiosity, wired back: 'Yes; and what happened to the crow?' (or cow). This elicited explanations which led to the proclamation of the district as a goldfield, and in consequence of the rush that followed in the same year (1888) 3493 ounces of gold were obtained."

Twenty-four miles from Coolgardie is Kalgoorlie mine, otherwise known as "Hannan's," the scene of many wonderful "finds," notable among which was that of a man who, to while away his time one Sunday, began to prospect under his tent and struck a rich "pocket." Unfortunately for him, he was so excited that he gave away the secret before he had pegged out his claim, and therefore forfeited all rights to ground other than what his tent actually covered.

Through accidents such as these West Australia, shut off by the desert from the eastern diggings, came into her own, despite the prophecies of geologists that the colony could not, according to scientific laws, contain any gold whatsoever. There are now seventeen recognised fields in West Australia: Kimberley, Pilbarra, West Pilbarra, Ashburton, Gascoyne, Peak Hill, Murchison, East Murchison, Mount Margaret, Yalgoo, North Coolgardie, Yilgarn, Coolgardie, Broad Arrow, East Coolgardie, North-East Coolgardie, and Dundas. Each field contains many mines, and between them they cover a total area of 324,569 square miles—eight times that of England! So much for the geologists!

The Coolgardie fields, on which our attention will be centred in the following pages of this chapter, lie about 350 miles east of Perth, on a plateau elevated more than 1200 feet above sea level. The plateau is crossed by a succession of sandy ridges, their crests separated by shallow valleys running north and south. Sandstorms and flies are its chief drawbacks. Whirlwinds, called "willy-willies" by the aborigines, spring up suddenly, spin madly along, seizing in their vortex dust, paper, and any other small objects which they may meet, and as suddenly die down. Unpleasant as they are, the high winds, which blow continuously for weeks together, are worse. An idea of their effect on the population may be gathered from the fact that fences four feet high have been completely buried by the sand-particles they sweep along in less than two years.

The great need of Western Australia is water. The annual rainfall averages but a few inches. Hence mining has, in many districts, to be carried on in a fashion accommodated to natural conditions. Water being absent, but wind very present, the shallow diggings are worked by the "dry-blowing" method. After the alluvium has been well shaken to bring the larger lumps to the surface for removal, the workman pours a panful of the "dirt" from a height of four or five feet into a second pan on the ground at his feet. He stands edge-ways to the wind, which blows away some of the dust but allows the heavier gold to fall perpendicularly. The pro-

cess must be repeated until only a little rubbish containing the gold is left. Then the miner begins to blow with his mouth, and as soon as he has removed what he can in this manner, he finishes off the separation with a little of his precious water. Corresponding to the cradle of river gold-washers is the "dry-blower," consisting of a couple of slanting frames fixed on legs so that the miner can shake the contents backwards and forwards, like a servant sifting ashes and cinders. The dirt, fed into a hopper having a bottom pierced with large holes, passes down the inclined screens, on the way losing its finer particles, which fall through. The coarser stuff passes over the end, while the gold flakes and nuggets collect behind the riffles placed to catch them. The fine matter is treated by hand in the manner already described. Twelve hundredweight of dirt can be treated by a "dry-blower" of this kind in one hour. More elaborate patterns, fitted with bellows to produce an artificial air current, handle several tons in the same time.

"Hannan's Brownhill" and "Great Boulder" are two of the principal lode mines. Their yields have been prodigious. In "The Land of Gold" Mr. Julius Price describes these two properties as he saw them a decade ago, when operations had only recently been begun by the proprietary companies. He descended the main shaft of Hannan's Brownhill, and, he says, "I was astonished to find that the whole place was positively sparkling with gold. I

had often pictured to myself what a gold mine would be like, but in my wildest dreams I had never imagined anything to equal this. The man (a miner) must have knocked out at least a hundred pounds' worth of ore during the few minutes I had been watching him in this veritable Aladdin's Cave. It absolutely made my mouth water to take up some of the lumps of stone lying loosely at my feet, whilst I could not help trying to realise the feelings of this poor digger, finding himself quite alone and surrounded by all this untold wealth which he was getting out for the benefit of others, whilst he himself was only earning £3, 10s. per week!" At the time of his visit the manager had under lock and key from twenty to thirty tons of pure gold!

This brief account of Westralian mines—brief it must be, through limitations of space—may fitly conclude with a glance at a huge engineering feat which has been performed in the interests of the goldfields. In almost all other gold-bearing districts of the world the metal has been found not far from a stream or natural reservoirs. We have already alluded to the great Californian system of pipes and flumes; and the reader will remember that some of these aqueducts are of great length. Unfortunately for Western Australia, the climate and configuration of the ground are such as to make it impossible to store rain water in sufficient quantities within easy reach of the mining centres. For separating gold dust from gravel and sand wind may serve;

but the quartz-crushing mills cannot do their work without a plentiful supply of water. Furthermore, where a scarcity prevails, disease, especially typhoid fever, is rampant.

The Government therefore determined to fetch pure water from the nearest copious springs. These happen to be in the Darling Range—near the coast—*three hundred and thirty miles* distant. The difficulty of piping the liquid is seriously increased by the fact that the Coolgardie district lies very high, practically a thousand feet above the source of supply; not to mention the existence of intervening belts of even greater altitude.

Truly an immense undertaking, the execution of which ranks among the greatest engineering feats of an engineering age!

The contract for the piping, which figured at £1,025,124—went to two Australian firms, Mr. Meysham Ferguson, of Melbourne, and Messrs. G. & C. Hoskins, of Sydney. Mr. Ferguson invented the "locking-bar" pipe, used thoughout on the scheme. The peculiarity of this form of pipe is that it is made of steel plates of semi-circular section fastened together along their edges with two longitudinal "locking-bars" of soft steel, the flanges of which are pressed on to the edges of the plates until a tight joint is effected. Owing to the absence of rivets and overlapping plates this type of conduit is quickly made and offers remarkably small frictional resistance to water passing through it. In com-

parison with cast-iron or "built-up" pipes it also scores under the heads of water-tightness, strength, and economy in hauling and handling.

By the courtesy of the proprietors of *Cassier's Magazine* we are permitted to quote the following description of this colossal work.

The Helena River was the site chosen to provide the supply for the fields, the flow being impounded at a point five miles from Mundaring Station and about twenty-five miles from Perth. Seventeen localities in all were inspected, and the position of the present dam site, where the hills converge to a narrow space and the country for miles round is flattened out, was apparently the best.

The top of the dam is 753 feet in length, traversed by a neat iron lattice bridge over the crest, which is 100 feet above the bed of the river. The dam tapers in thickness from 75 feet at the river bottom to 10 feet at the top. As a maximum the sheet of water will be thrown back six or seven miles. The quantity of water is set down at 4,600,000,000 gallons. Alongside the dam is a tower which gives access to a number of valves allowing the water to be drawn off at various levels, while at the foot of the wall a scour valve permits the removal of any silt which may accumulate.

Exterior to the dam and a little lower down the gully is the first pumping station, and the second one is only a mile and a half from it, but 400 feet above it. Here is situated a receiving tank with a

capacity close to half a million gallons. In all there are eight pumping stations and eleven tanks or reservoirs, with capacities from half a million to 12,000,000 gallons. The main service reservoir is 308 miles from the dam, and its capacity is 12,000,000 gallons. The minor service reservoir at Coolgardie holds a million, and the Mount Charlotte reservoir at Kalgoorlie, two million gallons. Receiving tanks of one million capacity were built at five of the pumping stations. A reserve tank for railway purposes was also built at a point along the route, and there are two regulating tanks holding 500,000 gallons.

The level of the water at the lowest off-take at the dam reservoir is 340 feet above the sea, but so rough is the country and rising, that within a little over three miles an altitude exceeding a thousand feet is reached. Twenty-four miles from the dam the regulating tank is 1065 feet above sea-level, and then it gradually drops 100 feet in the 12-mile interval. The next regulating tank is only 476 feet above the sea. After this the water flows by gravitation for 42 miles until it empties into the reservoir, which is 700 feet above the sea.

The next pumping station, 63 miles away, is 980 feet above sea level, and 32½ miles farther on is No. 5 pumping station, 1293 feet above sea level. The level varies only 32 feet within the next section of 46 miles, which terminates at No. 6 station. In another short length of 32 miles

a rise of 56 feet is experienced over the last. No. 7 section is 45 miles, and finds a rise of only 26 feet to No. 8 pumping station. Twelve miles farther is the site of the main service reservoir, at 1610 feet above the sea, and 1270 feet above the lowest take-off of the Mundaring reservoir.

From there the Coolgardie reservoir is 10½ miles, and the level 1515 feet above the sea, so that the water will drop 95 feet to Coolgardie, and from there to Mount Charlotte at Kalgoorlie, 27 miles away, there is a further drop of 160 feet, for the last reservoir is 1325 feet above the sea. Here, at a distance of 325 miles from the dam, the pipes at present terminate, but before long they will be extended "farther east."

Through the 30-inch pipe—the longest in the world—five million gallons flow daily into the heart of the sandy desert. We shall hear no more of Coolgardie folk paying 2s. 6d. per gallon for their water, or of store-keepers guarding the water-bottle more jealously than the whisky-jar. Abundance has been brought from a distance equal to that separating London from Berwick-on-Tweed; not to a huge metropolis, but to a mining town of a few thousand inhabitants. And what was the wizard which conjured up the scheme? Gold; already the creator of railways from the coast into the far interior. The magnetic influence of the precious metal has in half a century opened up Australia in a manner even more striking than the development

of the Great West after the Californian discoveries. Open your map of Australia and trace the railways. You will then follow in the steps of the gold-seekers, who plodded painfully on foot where the iron-horse now snorts with its heavy burdens.

CHAPTER VI

THE GOLD-MINES OF THE WITWATERSRAND

Gold and War—Value of these mines—Nature of Transvaal deposits—The Witwatersrand—"Banket"—Value of the "Banket" reef—The gold output—The "Essential Kaffir"—The labour supply—Recruiting—Chinamen imported—How the mines are worked—How the ore is treated—The cyanide process—Difference between Rand and other gold mines.

SOUTH AFRICA!

These words spell two things for the world in general and for Englishmen in particular—Gold, the producer of War; War, the consumer of Gold. Search the pages of history through and through, and where will you find a conflict approaching the great Boer war in magnitude, which can be directly traced to the hatred bred between nations by the rich treasures that have for ages lain hidden beneath the earth?

The rights and wrongs of that dreadful struggle between the unprogressive, but by no means despicable, Transvaal farmer, and one of Europe's greatest powers, we are not called upon to discuss here. Both nations fought with the courage of their convictions, determined to decide, whatever might be the cost, whether South Africa should belong to the Boer or to the Englishman. The wounds, physical and mental, received by the combatants are scarcely

yet closed. Severe commercial depression has followed behind the chariot of the war god, and years must still pass before the echoes of the contest have died away.

For the regeneration of exhausted South Africa to what do we look? To agriculture in the future; but to Gold for the present!

At the outbreak of the war the capitalisation of the Witwatersrand gold mines totalled £70,000,000 at *par*, and at market prices more than double that value. During 1898 no less than 4,295,609 ounces of gold were mined, representing £15,141,376 sterling. While the fighting lasted, these wonderful mines lay idle in most cases, the prey of inleaking water which there were no pumps to stem, for the workmen had either fled from the country or were carrying rifle and bandolier in its defence. Dividends fell to zero point. Thousands of shareholders found themselves forced to sell their scrip at a ruinous loss. But with the advent of British rule the pumps got to work again; stamps were repaired and added to; all available labour—its amount sadly diminished by the wealth that the Kaffirs had accumulated as camp followers—collected; and the Transvaal goldfields entered on the second era of their history.

The Transvaal mines are practically all reef mines. We have, therefore, no romantic stories of wonderful "finds" such as play so large a part in the annals of Orange Land and of the Antipodes. The Lydenburg

district first attracted notice in 1876. The De Kaap goldfields were discovered in 1884; and in 1885 a man named Arnold, working on the farm Langlaagte, broached the riches of the marvellous Witwatersrand deposits. Johannesburg, city of dust and gold-dust, was founded the following year, and in one decade a community of a few hundred people had swelled to a large town, which the census returns estimated to contain 107,000 inhabitants. Land increased prodigiously in value. Boers who had hitherto lived frugally on their farms suddenly blossomed out as the favourites of fortune.

What, then, is this district with the long name? The Witwatersrand is a range of hills running east and west, which separates the Limpopo basin on the north from the Vaal basin on the south. At some period early in the earth's history subterranean agencies heaved up the surface of the plateau, until the strata were broken and so much bent that their edges were exposed. The strata consisted of quartz, sandstone, and igneous rocks, sandwiched between which are layers of conglomerate, which from their appearance the Dutch named "banket," or almond-rock. The conglomerate contains very finely-divided gold, auriferous iron pyrites, copper, zinc, and antimony.

At the "outcrop"—*i.e.* the points at which the edges of the sandwich are exposed—the conglomerate is easily reached, and surface working is possible; but the farther the miner gets horizontally from the

outcrop the deeper he must go before he strikes the gold-bearing deposits. Owing to the "banket" strata being fairly close together, a single vertical shaft may cut through several in succession at various depths. For the first year or two in the history of the Rand goldfields deep-level mining was practically ignored, because the ore was not considered to be worth the expense of sinking deep shafts. Accordingly, attention was confined to claims within a few hundred feet of the outcrop. But when the conglomerate proved very rich, and when, in January 1890, the May Deep Level shaft struck the main reef at a considerable distance from the outcrop, the price of deep-level claims rose rapidly, and "the dividing line between valuable gold-mining claims and valueless veldt receded farther and farther from the outcrop." [1]

Experts have estimated that at 5000 feet from the outcrop the vertical depth will be only 2000 feet; at 8000 feet, rather more than 4000 feet; and at a distance of three miles about 7000 feet. The "Simmer and Jack," sunk from a point 4000 feet horizontally from the outcrop of the Main Reef, struck it when the shaft had reached a depth of 2400 feet, or rather less than half a mile.

As conditions in the Transvaal appear to be very favourable to deep mining, there are no physical difficulties to prevent the sinking of shafts one and a-half miles deep. So far as operations have been carried, the reef has proved very reliable, being struck

reliable

[1] "The Gold Mines of the Rand," Hatch & Chalmers.

within a few feet of the calculated depth. Mr. Hays Hammond, one of the greatest authorities on the metallurgy of the Transvaal, contributes the following opinion to *Cassier's Magazine*:—

"It is estimated that for every mile in length along the course of the reefs, down to a vertical depth of 1000 feet for the dip of these reefs, gold to the value of about £10,000,000 will be extracted. This is a conservative estimate—at least as applied to the central section of the Rand. If we assume these conditions to obtain to a depth of 6000 feet vertically, we have the enormous sum of £60,000,000 for each mile in length. It is not unreasonable to suppose that these conditions will be maintained along most of the central section, say for a distance of ten miles, in which case we would have an auriferous area, within practicable mining depths, containing upwards of £600,000,000 value of gold. It is less safe to make any prediction of the gold product to be expected from the east and west sections; but it is perfectly safe to say that the output of these sections would very greatly augment the amount I have named. Messrs. Hatch and Chalmers, well known engineers of extensive South African experience, compute the available gold from these portions of the Rand at £200,000,000."

A treasure well worth winning! During the eight months preceding the outbreak of the Boer war in 1899 the Witwatersrand produced £12,405,032 sterling. But for the necessary stoppage of the

mines the year's take would have touched twenty millions sterling, a figure that rivals those of the most palmy days of California and Australia. No less than 71 per cent. of the yield came from the central (Johannesburg) section of the Rand; and 24 per cent. was raised from the deep-level workings.

The total gold product of the Rand in that year represented a quarter of the gold mined throughout the world; and with a steady development South Africa will undoubtedly take first place among all Eldorados.

From other goldfields those of the Transvaal differ in one important particular, viz., in the labour used. Here all purely manual, and some skilled work, is performed by natives. The Kaffirs, or "boys," as they are universally called in South Africa, drill, shovel, lay tracks, do the timbering, tramming, ore-sorting, stoking, &c. Skilled labourers, such as fitters, carpenters, engine-drivers, are of white nationalities, and command very high wages.

The "Essential Kaffir" well deserves his adjective. Without his help the gold-mines could never have been developed, as the climate, though healthy, soon tells upon the European or American who has to do hard physical work below ground. There is the further difficulty that where white and coloured men are engaged on the same job, the nature of their respective duties must be clearly separated, the white directing, the others obeying. If well supervised, the Kaffir can use the pick or drill as effectively as he did

his assegai before the white man put a stop to inter-tribal raiding.

A problem which African mine-owners have had to face from the beginning is that relating to the *supply* of labour. By nature the Kaffir is a lazy fellow, well content to till his little maize plot—or, rather, let his wives till it—sit in the sun, and smoke. His one incentive to labour under the sway of the white man is the desire to accumulate wealth which will enable him to buy wives—or more wives if he be already married—an estate, and the finery in which he loves to deck himself out—the "top-hat" of civilisation forming an important item in his wardrobe. Before the war over 100,000 natives were at work in the mines. The war either frightened most of these away, or gave them employment as bullock-drivers. Those who went stayed away; those who remained in the Transvaal earned sufficient money to retire for a long time to their kraals. So that when the fighting was over labour became very scarce. Experts estimated the shortage of hands for the mines alone to reach 129,000; and agriculture to be proportionately handicapped.

It had been found necessary, as early as 1893, to establish a Native Labour Department for providing an adequate inflow of workmen. The northern parts of the Transvaal were first tapped by white men who travelled about engaging the Kaffirs to work under contract for stated periods of service. A depot was established at Pietpotgieter's Rust; another

at Zandfontein, and a third at Pretoria, the intervals being broken by buildings to serve as shelters and rest-houses for the gangs travelling south. Every recruit had to be vaccinated, fed, and housed. From Pretoria the Kaffirs were carried by train to the Rand, where they occupied the compounds adjoining each mine. The system worked very well, as it protected the natives both on their journeys and when "in residence" at the gold-fields.

But, unfortunately, licences for the sale of alcoholic drinks were freely granted by the Boer authorities to traders in the compounds, who did a brisk business with the Kaffir, to whom "fire-water" is the *summum bonum* of life, and to be indulged in as freely as funds permit. So, while on the one hand some men made fortunes out of the traffic, on the other the efficiency of native labour was so much impaired as to provide the "Uitlanders" with a genuine grievance against the Boer Executive, which looked callously on.

The recruiting system has been revived, but not with its former success. For two years depression reigned supreme in Johannesburg; the mines were many, but the labourers were few. At the end of December things had become so desperate that Sir George Farrar moved a resolution in the Transvaal Legislative Council to the effect that the Government should introduce an Ordinance "providing for the importation of indentured unskilled coloured labourers to supplement the labour supply of the

Witwatersrand." The matter was referred to the Home Government, and, after warm discussion in the House of Commons, the Transvaal received permission to introduce Chinese labour under certain restrictions. Round the question of the "yellow invasion" violent controversy has raged; those favouring the importation of Celestials urging that without some such measure the Transvaal must lapse into bankruptcy, and the supply of African labour could not possibly meet the demand; their opponents warmly upholding the view that with time Kaffirs would flock in, and that in the meanwhile much greater use might be made underground of labour-saving machinery, which is strikingly absent from some South African mines.

Anyhow, a batch of 1047 Chinese arrived on June 10, 1904, *en route* to the New Comet Mine, and before the end of the year 19,444 pigtails wagged in the compounds of the Rand. There is no workman in the world to beat the Chinaman for docility, quickness, and industry. He has already made his mark on the output; and very probably the Kaffir, seeing that he no longer has the mine-owner at his mercy, may become scared and seek a job before all the berths are filled up.

From the labour question, which has become the peg for partisan orators to hang up their wares on, let us divert our attention to the actual working of the mines.

The Rand is dotted over with tall chimneys, huge

wheels, and ugly buildings containing mills, hoisting engines, and pumps. These indicate the mouths of shafts, which are vertical or inclined, according to the position of the property.

We will suppose that the particular mine taken as typical of the Rand "propositions," as a Yankee would say, is at a distance of 500 feet from the outcrop of the reefs, runs 2000 feet east and west, and 1000 feet north and south. Being so near the outcrop, the portion of the reef underlying the property dips at a big angle to the horizontal. The manager therefore sinks a vertical mainshaft near the boundary vertically nearest to the reef; and when the reef has been struck continues the shaft parallel to the reef in the stratum beneath it. From the shaft, at different levels, usually 150 feet apart, "cross-cuts" are made north and south into the reef, and from these again "drives" are cut east and west through the reef itself. The drives are connected by "winzes," which, together with the drives, divide the reef into blocks—called "stopes" —of ore. The operation of cutting out the blocks, removing the valuable parts, and filling in the cavities with the rubbish, or with material lowered from above, is termed "stoping." "Underhand" stoping signifies the method of working downwards from an upper drive to the drive below, while "overhand" stoping expresses the reverse process. In the first case—underhand stoping is most usual on the Rand as being more easily learnt by unskilled

labourers—the ore is shot down the nearest winze to the level below, where it is caught in cars, and transported through the cross-cuts to the shaft. The latter has a section varying in dimensions within timbers from 11 feet by 5 feet to 26 feet by 6 feet; is strongly timbered at the sides, and divided into several compartments for skips and cages.

Should overhand stoping be adopted, the roof of the level is strongly timbered or protected by a strip of reef left over it. The miners then get to work, hacking at the roof, passing good stuff through a vertical "ore pass" into the cars in the level below, and building up a sloping bank of rubbish which has its upper face parallel to the lower surface of the stope. Sometimes "breast stoping" is preferred, *i.e.* attacking the block almost vertically, so that it may be termed a very perpendicular variety of the underhand method.

Dynamite monopoly

Ore is loosened with the aid of dynamite placed in the bottom of holes drilled by hand or machinery. The high price of this commodity, when the Boers held the monopoly of supplying it, was one of the chief causes of friction between the Uitlanders and the Pretorian Government.

The "banket" is made up of white quartz pebbles cemented together by a bluish substance containing iron pyrites and gold. In the beginning of things the three materials were probably merely mixed without adhesion; but at some later period, when

the granite pushed up the reefs, great heat forced and combined them into their present condition.

When a reef is very thin—sometimes it dwindles to a few inches—the miners are obliged to hack away a sufficient amount of the native rock on both sides to give them room to work in. A part of this useless material serves to form "stulls," or supports, between the walls of the lode.

From the mines the ore is wound up in skips and tipped automatically into ore bins or trucks, which carry it off to the sorting-house. There it is fed into a hopper, washed, and dropped, a little at a time, on to the sorting table or sorting conveyor, according to the practice of that particular mine.

The former is a circular, revolving counter, 30 feet or more in its external diameter; the centre being an open space 6 yards in diameter. "Boys" stand all round on both sides and, as the table slowly revolves, pick off all the rubbish. A scraper is continually shooting what passes their inspection into a crushing machine, which pounds it into lumps about the size of road-mending granite.

In some mines the table is replaced by an endless-belt conveyor, an American invention.

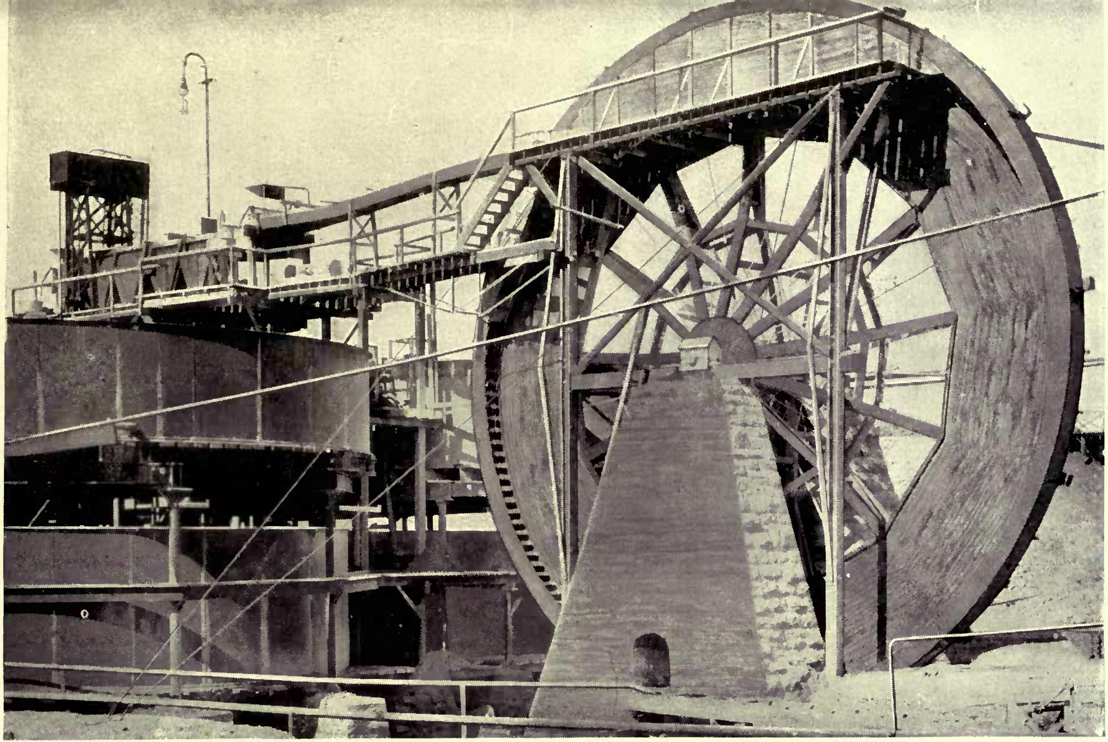
After the preliminary crushing the ore is transported by trucks or indiarubber belts to the mills, where great stamps stand in a double row, each stamp fed by its own bin. A heavy vertical bar, shod at the bottom with a steel shoe 9 inches in diameter, and furnished with a projection near the

top, is raised and dropped 90 times a minute by a cam on a horizontal revolving bar. It falls about 9 inches, and crushes the ore, fed by a hopper, against a steel die of equal diameter. Altogether, the pestle weighs upwards of 2000 lbs. ?

The pulverised material, called pulp, passes through fine screens on to inclined copper plates coated with mercury, which swallows most of the fine gold, and, when fully saturated, is retorted to separate the metals. About 40 per cent. of the gold stays in the "tailings," which have to be treated chemically. They are first shaken in a "Frue" vanner, an endless belt which is given a lateral and a progressive motion simultaneously, while a stream of water passing over the stuff removes the lighter portions—called "slimes."

The "concentrates," or heavier parts, are now lifted by buckets on the circumference of an enormous wheel into a trough, through which they flow into the cyanide vats, of a capacity of some hundreds of tons each. The vats are filled with a solution containing 2.25, 2.0, or 1.0 per cent. of cyanide of potassium, which, like mercury, has a great affinity for gold. After soaking in this solution for a week, the concentrates are drained, the solids being cast out on to the tailing heaps which plague Johannesburg sadly during high winds, and the solution is taken to the precipitation boxes. The gold must now be separated from the cyanide, with which it has chemically combined. So to the potassium is thrown food which it likes even better than gold,

 Ka. Ka.



A Cyanide Plant at the Rand Mines. The huge wheel shown raises the gold "concentrates" from the stamps [illegible] trough through which they flow to the circular cyanide vats. These separate the gold from the rubbish

—zinc; and as it absorbs this it lets go of the more precious metal. The gold settles in a shining deposit, which is dried and melted in crucibles. And so, at the end of several days, there is seen a solid ingot containing 80 per cent. of gold and 10 per cent. of silver.

This short account shows the reader how vastly more complicated reef mining is than placer mining. The simple pan, rocker, or sluice, have been replaced by machinery of a high order, and by chemical processes discovered after much careful laboratory research. The prevalence of machinery, the absence of the individual miner working for his own hand, the good supply of water, the abundance of provisions and other necessaries, all distinguish the Witwatersrand from the goldfields of Australia and America. Almost from the very first days, the Transvaal gold has been attacked by companies backed up by capital, under conditions which lacked the usual hardships of the goldseeker's lot.

CHAPTER VII

THE ELDORADO OF THE NORTH

The *Excelsior* arrives in 'Frisco Bay—California upset—The Yukon district—The early approaches thither—Forty-Mile—George Carmack's find—A unique episode in gold-mining history—The reward of laziness—Wonderful earnings—Melting the ground—The "clean-up"—Fortunes made—A rush to the Klondike—The Chilkoot and White Passes—Down the Yukon—Terrible mortality among baggage animals in the White Pass—Growth of Dawson—High prices—Dawson of to-day—The Klondike "placers"—Mining laws—How Alaska is being opened up—The White Pass Railway—Alaska's future.

ONE July day in 1897 a small steamer, the *Excelsior*, steamed into San Francisco harbour with a cargo that would have shamed many a Spanish galleon of old times. The passengers were miners, their faces scarred by much hardship and privation. About their personal appearance there was beyond this nothing remarkable; but they brought with them, tied up in sacks, skins, old clothes, tins, jam-pots, and every imaginable article that would hold it, gold dust,—precious gold dust and nuggets, a full ton in weight. From that moment millions of tongues began to wag about the marvellous Tom Tiddler's ground in Alaska and North-West Canada, where gold could be got almost for the trouble of picking it up. So the report ran, and gossip soon bred a fever which caused men of all classes to quit

their work and hurry off to secure in the distant goldfields, after a few months' labour, enough wealth to furnish them with a comfortable livelihood for the rest of their lives. The "rushes" to California and the Australian goldfields in the middle of the century were paralleled, even if not surpassed. Physical obstacles could not deter the adventurer—clerk, mechanic, government official, or aristocrat, the thirst for the precious metal blinded his eyes to the coming and well-known terrors of precipitous, snow-clad mountains. Off he went, full of hope, but often miserably supplied with a proper outfit, destined, in many cases, to leave his bones in the passes, or at the bottom of the swirling Yukon. The lucky few made their fortunes in these early years of the boom, but they were the few.

Before proceeding to an account of the Yukon goldfields as they are to-day, let us glance at the early history of the discovery of the vast gold-bearing gravel regions which cover many thousands of square miles on both banks of the mighty Yukon, a river ranking very high among the great streams of the world in point of both length and volume. For sixteen hundred miles the Yukon is navigable by craft of the size of the largest Mississippi steamers, and for five hundred miles above that by boats of half that size. Rising in the lakes on the north flank of the St. Elias Range, at about the 60th parallel of north latitude, the river makes a huge sweep northwards; at Fort Yukon, 350 miles north,

just touches the Arctic Circle; and bends southwards again to its mouth. About 1600 miles up from the sea is the great gold-scattered tract to which men are hurrying, 300 miles nearer the Pole than St. Petersburg. At midsummer twenty-two out of the twenty-four hours are brightened by the sun, shining down with almost tropical heat. At midwinter darkness claims an equal proportion of the day, and cold lays an icy grip on the country which is not slackened for months. Herein lies the main difference between the early Klondike and the other great gold-fields of the world. A man might be lost in California, Africa, or Australia, and yet manage to find his way out. But not so here, "Once in always in," after the winter had commenced; and to lose one's way was to perish.

Until recent years the Klondike region—as large as France—was practically a *terra incognita*, traversed by a few Esquimaux, Indians, and half-breeds, and here and there a white fox-hunting trapper. The bears had the district pretty well to themselves. In or about 1878 the first gold-prospector entered the country, and from that time onwards small parties of miners made their way into the Klondike over the Chilkoot Pass from Dyea at the head of the Lynn Canal. From the outset gold was found in the bars of the Lewes River (the upper Yukon) and its tributaries, but generally in unremunerative amounts, considering the conditions under which mining had to be conducted in a region so re-

Drilling blast holes in a Rand Mine with Ingersoll Sergeant air-drills. The machines are fed through tubes with high pressure air from steam compressors stationed above ground. These drills make upwards of

mote from civilisation. In 1881, however, paying "placers" were discovered on the Big Salmon River, and five years later the Cassiar Bar was tapped. In the autumn of that year miners struck "coarse" gold on Forty-Mile Creek, a feeder of the Yukon which enters it just to the east of the boundary line between Canada and Alaska. "The gold," wrote Dr. Dawson—who afterwards gave his name to the chief city of the region—"varies much in character, but is quite often coarse and nuggety, and very large amounts have been taken out in favourable places by individual miners. Few of the men mining here in 1887 were content with ground yielding less than 14 dollars a day, and several had taken out nearly 100 dollars a day for a short time."

A "city" quickly sprang up at Forty-Mile, whither 200 out of 250 miners of the district hastened: and another at Circle, 100 miles lower down, in Alaska. These soon expanded into places more worthy of their title.

A year which will always remain famous in mining history is 1896, when a miner named George Carmack, who had been diligently searching for eleven years, tapped the riches of the Klondike River. While roaming about with his Indian relatives and friends, he started digging on the banks of the Bonanza Creek, and soon found enough gold in his pan to convince him that here was a fortune. He at once hurried off to Forty-Mile to register

his claim, and after giving some old acquaintances the hint, he started back. This was in August, just as the winter, which would effectively bar the people of the outer world from entering, had begun.

In a few days all Forty-Mile was on the way, and soon 350 men—who had the place *all to themselves*—were shovelling at the richest-known gold deposits in the world. Never had miners had such a chance! They knew that for several months no one could arrive to share the spoil. Fortunes were made at an astounding rate. Carmack and three companions washed out 1200 dollars in eight days; while on the same creek two other men took 4000 dollars in two days. Newcomers staked out Creek claims farther and farther from the main stream of the Klondike, until the people from Forty-Mile had all been served. Presently the Yankee miners from Circle City got wind of the find, and rushed up, suffering terribly on the way from cold and hunger.

One of the most curious things connected with this strike was the rich reward that attended an act of sheer laziness. An ex-bar-tender of Forty-Mile, who was too sluggish to go up to the top of the Bonanza Creek, turned aside into a subsidiary Creek, the famous Eldorado, out of which he made nearly £600,000.

So rich was the "pay dirt," that as much as £160 was taken out of a single pan. On one claim a nugget was picked up worth £51, on another one worth £46.

The gold took a lot of getting out, however, the ground being frozen hard as iron. Yet the digging must be done in winter, since after the spring thaw set in every shaft became a well, owing to the leakage from the upper gravel stratum, and because, though it would be impossible to wash the dirt when the thermometer was many degrees below zero, the abundance of summer water would make the "clean-up" an easy matter. While sinking the shafts the miners had to use big fires to soften the gravel. By the time a fire had burnt out, the ground below it was thawed to a depth of several inches. Pick and shovel removed all the loose dirt, which was thrown on to the "dump," ready for washing in the spring. Alternate firing and digging gradually penetrated the crust of gravel to within a few feet of the unworkable bedrock below, and then the real excitement began, for the rich pay-streak rests on the rock, which has caught all the gold washed through the ground by centuries of rain and movement.

The last eighteen inches or so of gravel is laid by itself on the dump and treated with special care, that the dust and nuggets which it contains may be secured. In deeper claims, *i.e.* those where the rock is overlaid by very deep gravel, it would be too troublesome to dig out all the super-incumbent "poor dirt"; and small shafts are sunk to the rock, and horizontal "drifts" run from the bottom through the rich strata. The frozen condition of the earth

here aids the miner, by saving him the labour of supporting the roof of a drift with timber props.

All the winter long the miners burnt and dug, piling up great heaps of the precious dirt. With the spring began the "clean-up," which yielded most sensational results. Some men made money at the rate of *seventeen dollars a minute*, and fortunes of hundreds of thousands of dollars came out in a couple of months. One miner was found looking very disconsolate, and on being asked what ailed him he replied that for the last day or two he had been making only 60 dollars per pan washed, in place of the 100 dollars that his earlier washings produced!

Of all the 300 claims staked out on Bonanza Creek not one proved a failure. Many fortunes were found in the sluices and pans; and even among the refuse thrown away enough gold remained to bring wealth to any one who cared to work it over again.

At the end of the "clean-up" a large proportion of the miners were "made" men for life. Yet, by a strange irony of fortune, they were so pinched by want of food that one man offered half his wealth in exchange for a single good square meal. The first steamer down the river carried on board nearly a hundred lucky miners, who, as mentioned above, reached San Francisco safely with their spoil. "As the United States Mint was closed for the day," writes a witness of the scene in the New York

Tribune, "when the miners arrived, they packed their sacks of gold dust to Selby's office. There a picturesque collection of bags was produced. Some were made of deer hide, and held as much as £2500. Several of the miners ran out of even canvas bags, and were forced to put their gold in tumblers and fruit jars, which they covered with writing paper. They looked like fruit or jelly put up by country housewives. All the bags were weighed, and then, as fast as the weight was recorded, they were slit open with a sharp knife and the contents poured upon the broad counter, which had a depression in the middle. The heap of gold dust looked like a pile of yellow shelled corn."

Thousands of gold-seekers of both sexes and all classes were soon hurrying to Pacific ports, bound for Klondike, not caring *how* they should reach the happy hunting-grounds, as long as they got there. The mining towns of Colorado and California were deserted by their inhabitants, who turned what they could into money and joined the rush. The fever spread rapidly to inland towns, even to Europe and Australia. Men of all ranks threw up their ordinary occupations and shipped for Alaska. At Seattle, Washington, half the police force resigned, and the street cars had to cease running for lack of drivers.

By every mail came in fresh accounts of the Klondike wonders, some doubtless very greatly exaggerated. The following, which appeared in the *Manchester Guardian* of October 17, 1897, is, how-

ever, the statement of a responsible person, Mr. William Ogilvie, a Canadian Government Surveyor, and as such may be trusted. "Talking of the reports of wonderful accounts of gold taken out in a single pan, Mr. Ogilvie gave some of his own experiences. He went into one of the richest claims and asked to be allowed to wash out a panful of gold. The pay-streak was then very rich, but standing at the bottom of the shaft, looking at it by the light of a candle, all that could be seen of the pay-streak was a yellowish-looking dirt, with here and there the sparkle of a little gold. Mr. Ogilvie took out a big panful and began to wash it out, while several miners stood about guessing as to the result. Five hundred dollars was the top guess of the miners, but when the gold was washed, dried, and weighed, it came to a little over 590 dollars."

How were the gold-seekers to reach the land of promise? Though no fewer than nine routes were practicable in the summer, three only were generally employed. The easiest and longest was an all-water route, by steamer to the mouth of the Yukon, and thence up the river, a distance of 4000 miles in all. This occupied any period up to a month, though, if the river steamer were unlucky, a much longer time might be required to pilot her through the many snags and sandbars lurking in the unsurveyed channel of the Yukon. Impatient people therefore preferred the overland route — some 2500 miles

shorter—*viâ* the Chilkoot and White Passes of the St. Elias Range. If he meant to utilise one of these, the adventurer booked a passage to Juneau, where the outfit—mining tools, cooking apparatus, clothes, guns, and large quantities of provisions sufficient to last for six months—must be purchased. Having laid out his money to the best advantage, he proceeded to Dyea or Skagway at the head of the Lynn Canal, according to whether his choice was the Chilkoot or the White Pass. At either place, owing to the shallow anchorage, the traveller often had to wade ashore. (?) Then he rigged up a tent, and sought porters to carry his goods to the foot of the Pass. We will picture the fortunes of an 1897 gold-seeker in the Chilkoot. First came a nine-mile tramp over very rough ground to Sheep Camp, at the rate of a mile an hour. He had to make several journeys over this piece if carriers were few and his baggage bulky. This took about four days. At Sheep Camp wood was scarce and a fire sorely needed. Porters having been engaged, the mountains proper must be tackled. Absolutely no vestige of a trail existed over the snowy plateaux which rose in front, cut across by deep crevasses, the work of some raging mountain stream. If a blizzard overtook the party—as very often happened—they had to stop, roll themselves up as best they might, and wait until the storm abated. The last part of the ascent was terrible, an almost perpendicular climb up rocks where a boulder might easily be dislodged and sent crashing

down on some luckless person below. "I have roughed it," said Mr. Harry de Windt,[1] "for the past fifteen years in Siberia, in Borneo, and in Chinese Tartary, but I can safely describe that climb over the Chilkoot as the severest physical experience of my life."

In 1898 an aërial wire-rope tramway was established to transport baggage up this precipice, at the rate of a cent a pound.

From the top the descent inland was so precipitous that sleighs had to be "given their head," as it was impossible to hold them back. Then came a succession of journeys to Crater Lake, from which place Lake Lindeman, the first of a chain, was soon reached; and a couple more days brought him to Lake Bennet.

The traveller's troubles were by no means over, for he must now *build a boat*, raft—something to carry him five hundred miles through lakes and rapids. This was a difficult job even for a professional boat-builder, as trees must be felled and cut into planks before he could think of beginning work on his craft. If fortunate, he might possibly pick up a ready-made skiff for 100 dollars or so. Ten chances to one there was not such a thing for sale. Of course, if the outfit did not include all proper tools and materials for caulking the boat's seams, an advance became almost impossible. Here is a picture of Lake Bennet in June 1898: "It was

[1] *Strand Magazine*, October 1897.

First tourist excursion, Pacific and Arctic Railway, July 24, 1898. The railway, which runs from Skagway on the Lynn Canal, to the head waters of the Yukon, was built in the face of physical difficulties such as the engineer

a busy shipbuilding port, turning out more boats in a given time than probably any other town in the world, large or small. The skilled and the unskilled were hewing and caulking, all bent upon the one common theme of having a boat, and by means of it reaching Dawson or some place in near proximity to the goldfields. No more inspiring lesson teaching man's ingenuity and determination could be found than this one of Nature's shipyard. One and all seemed to have got suited and fitted, and within a period of some two months not less than two thousand craft—sail boats, scows, and canoes, many of the lighter ones brought bodily over the passes—were launched upon the still icy waters of Lake Bennet."[1]

Leaving the lakes, the voyager entered the Upper Yukon, and soon reached the Grand Canon Rapids, nearly a mile long, where the river is suddenly contracted to a width of 100 feet. The waves run high, and if the boat should be swamped, there is little chance of getting out, as the sides are sheer rock. From here to the White Horse Rapids, known as "the Miner's Grave," from the many casualties that have taken place in their turbulent waters, is very bad going. At the Rapids a portage must be made. Lake Le Barge is next reached, a lovely piece of water with practically no current flowing through it. Then the river again, and its strong stream carrying the boat sixty to seventy miles a day. On

[1] "Alaska and the Klondike," A. Heilprin.

past Little Salmon River to Five Fingers Rapids, Rush Rapids, and Rink Rapids, after which the dangers of travel are pretty well over, and the Klondike is reached at last.

Should the White Pass have been chosen, the difficulties of the mountains were lessened, partly because the gradients are not so severe, partly because it has an altitude of over 1000 feet less than the Chilkoot. The distance, about forty miles from Skagway, the port of landing, could, under favourable circumstances, be covered in a day and a half. From Lake Bennet the route is the same as that already described. During the "rush" of '98 this Pass was largely used; and sad traces of man's cupidity remained to mark the event. "The Desert of Sahara," writes Mr. Heilprin, after crossing the Pass in 1898, "with its lines of skeletons, can boast of no such exhibition of carcasses. Long before Bennet was reached, I had taken count of more than a thousand unfortunates (horses) whose bodies now made part of the trail; frequently we were obliged to pass directly over these ghastly figures of hide, and sometimes, indeed, broke into them. Men whose veracity need not be questioned assured me that what I saw was in no way the full picture of the 'life' of the trail; the carcasses of that time were less than one-third of the full number which in April and May gave grim character to the route to the new Eldorado. Equally spread out, this number would mean one dead animal for every

sixty feet of distance! The poor beasts succumbed not so much to the hardships of the trail as to lack of care and the inhuman treatment which they received at the hands of their owners. Once out of the line of the mad rush, perhaps unable to extricate themselves from the holding meshes of soft snow and of quagmires, they were allowed to remain where they were, a food offering to the army of carrion eaters which were hovering about, only too certain of the meal which was being prepared for them. Oftentimes pack-saddles, and sometimes even the packs, were allowed to remain with the struggling or sunken animal—such was the mad race which the greed of gold inspired."

After the 1897 rush Dawson, the "Francisco of the North," as it has been called, sprang up on the right bank of the Yukon in the angle between that river and the Klondike. On the opposite side of the Klondike is the town named after it. Early in 1897 Dawson was only a small group of huts, housing a few hundred miners. No less than 5000 entered the Yukon country in the summer of that year, and about 40,000 in the summer following. By the autumn of 1898 Dawson counted at least 20,000 inhabitants, and had all the usual features of a "boom" town. That is to say, most of the buildings were of a somewhat ramshackle nature; and prices ruled high. Supplies came in very irregularly by steamers from St. Michael's. The population was not a mere horde of prospectors intent

upon acquiring gold at all costs, but a medley in which Counts, naval and military officers, scientists, lawyers, pressmen, and storekeepers jostled one another. You had your choice of three weekly newspapers, several theatres (of a sort), an almost unlimited number of saloons, and a couple of banks. The insecurity of life and property usually associated with mining towns did not exist here, thanks mainly to the efficiency of the Canadian Mounted Police. So much did people trust one another, that if a purchaser entered a store, he said what he wished to have, threw his bag of gold-dust on the counter, and *turned his back* while the storekeeper weighed it out. To watch him would have been flagrantly "bad form," as implying mistrust of his honesty. One storekeeper *did* take a mean advantage of a customer; and he was promptly removed in a manner resorted to in communities where rough justice and revolvers form judge and executioner.

A Dawson hotel was not much to look at in those days; but what it lacked in comforts it made up for in charges. A guest-room was generally innocent of looking-glass, washing apparatus, candlestick, window-panes (replaced by canvas). But for what it could boast in the way of a bed 26 shillings a night might be asked. Board cost about 20 shillings more a day. Yet as regards the commissariat the figure is not excessive in view of current prices. Mr. Heilprin details some of these: oranges and lemons 75 cents apiece; apples 25 cents; potatoes

and onions 75 cents the pound; butter 1 dollar the pound; eggs, presumably fresh, but ordinarily with a stale inheritance, 2½ dollars per dozen; Bass's ale 2½ dollars a pint; sugar 30 cents a pound. Water-melons, for which the Yankee has a loving tooth, could not be bought for less than 25 dollars each; and in scarce times a cucumber fetched 5 dollars. Hay touched tremendous prices — 1400 dollars per ton.

All this has, of course, been changed by the improvement in methods of communication. From the middle of May till the middle of October about fifty-five stern-wheel steamboats ply between Dawson and St. Michael's. The pilots know the snags, bars, and channel-ways of the Yukon as well as those of the Mississippi. As the river in its broader parts has a current of only three miles an hour, the powerful engines drive the boats up the 1600 miles in about nine days, and down in a much shorter time. When the river freezes, the sleigh traffic begins over the smooth ice at its edge, both from St. Michael's and from the upper lakes inside the passes.

Marvellous indeed is the change that has come over the township. "It has," says a writer in *The World's Work*, speaking of the year 1903, "a splendid system of waterworks, a local telephone system, and long-distance connections with the principal mines; telegraphic communication with the world, churches of every denomination, large Federal and Municipal buildings, and good schools. . . . The streets are

all thoroughly lighted by electricity. Lines of steamboats along the wharves, loading and unloading, and steam dredges at work in the river, give an animated aspect to the water-front. Three years ago the inhabitants of Dawson lived principally on dried and canned meats and German sliced evaporated potatoes. To-day fresh meat is brought in, frozen in winter, and in refrigerator cars to White Horse in summer, and all vegetables are grown in market gardens near by. Nothing pleases the Dawson citizen more than to entertain a sceptical visitor from the South at table with lettuce, asparagus, green peas, or celery, cauliflower, cabbage and carrots, according to the season, grown in his own rear-yard."[1]

About three miles up the Klondike River from Dawson is the Bonanza Creek, the scene of the first important finds. Following the Bonanza thirteen miles or so the Eldorado Creek is struck. The trail formerly used by the miners was much impeded by morasses, through which the pedestrian ploughed his way, trusting to his high waterproof boots to keep out most of the wet. But matters have been much improved since then, and the claim-owner reaches his property without much trouble. In winter sleighs are largely used over the streams, up which a good dog-team will make the journey to Eldorado in three hours.

A few words about the Klondike "placers" or surface claims. To the prospector the Eldorado

[1] November 1903.

looked unpromising enough, with its dense overgrowth of bushes, trees, and moss. He might easily have passed through the valleys without suspecting that under that shaggy mantle lay vast quantities of "gravel" — pebbles chipped off the rocks of the region by water and worn to smoothness—among which lurked mingled clay and gold, the latter increasing in bulk at bed-rock level. A "creek" claim, *i.e.* one including a length of the stream, is 250 feet long, measured in the general direction of the creek. The breadth varies with the nature of the slopes on either side. If the slopes are gentle, the line drawn horizontally at a level three feet above the edge of the water, may run several hundreds of feet before the rim-rock of the slopes is reached. So a maximum breadth of 1000 feet has been fixed by the mining laws. A "river" claim can be staked out on one side only of the stream, and has the same maximum area as the creek claim; and a "hill" claim is similarly restricted. All other placer claims are 250 feet square.

The Canadian Government reserves every alternate ten claims, which can be disposed of in the way most advantageous to the authorities. Any trespasser upon a Crown claim loses such rights as he may have secured previously in private claims. To encourage discovery, any miner or party of miners who strike a new mine gets claims of double size up to two members.

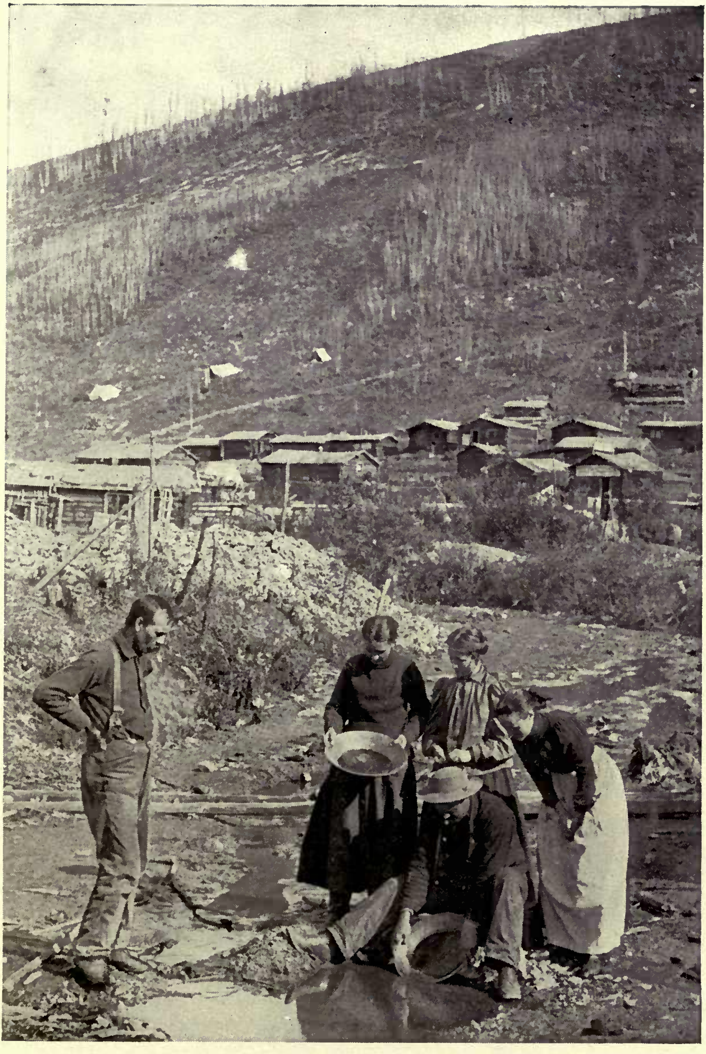
Though no miner can receive a grant of more

than one claim in one district, he is at liberty to purchase the claims of other people; and many fortunes have been made by individuals who bought what the previous owners considered to be worthless properties. In order to prevent useless occupation of a claim it is stipulated that if an occupier fails to work his claim for seventy-two consecutive hours he forfeits his rights to it, unless a satisfactory reason can be assigned for his absence.

It would be tedious to enumerate the dozens of other rules and regulations prevailing in the district; and it must suffice to add that illegal "jumping" of claims—an unsavoury feature of the Californian and Australian goldfields—is unknown in the Klondike.

On the Bonanza and Eldorado, which by now have been largely worked out, the primitive method of panning has been replaced by scientific sluicing and high pressure hydraulicing. The output of the Klondike region showed, at least till 1902, some fluctuation, but very large totals. In 1899 the miners won 16 million dollars; in 1900, 22¼ millions; in 1901, 18 millions; and 20 millions in 1902.

Doubtless the time will come when more capital than at present will be spent on large dredgers to scoop up the deposits of the sand-bars and river beds, and pass them through sluicing-boxes. With an effective bucket-dredger, a very small yield of gold per cubic yard more than repays the cost of working. The method has been used, as we have seen, very successfully in California.



"Panning" at the junction of the Eldorado and Bonanza Creeks, Klondike. The gold-seeker partially fills the pan with gold, dirt, and water, and by a peculiar circular motion flips the lighter stuff over the lip of the pan, while letting the gold remain at the bottom.

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The Eldorado of the North

"Miners—gold-miners—have always done more than any other class of people toward developing the resources of the West. Were it not for the discovery of gold in California of 1849 there would not have been built a trans-continental railway until many years after 1868, and to-day much of the great country west of the Mississippi River would be practically a wilderness." These words,[1] written of California, apply equally to North-West Canada and Alaska. The development of the huge tract, as large as all Europe, Russia excluded, during the last decade has been nothing short of phenomenal. Alaska, like other sub-arctic countries, is subject to great extremes of temperature—95° Fahrenheit in the summer, 70° to 80° below zero in the winter. A person travelling up the Yukon in the warmer months would be astonished by what he saw after what he had read. Not a vestige of snow in sight, but flanking the river matted, luxuriant vegetation. Wheat of fine quality is now raised in Alaska, also stock. Besides gold, there are rich deposits of iron, nickel, copper, coal, only awaiting the advent of the railway to be mined in large quantities.

Already the iron horse has arrived. In June 1898 a syndicate of English capitalists began work on what is now known as the White Pass and Yukon Railway, running from Skagway through the mountains to Lake Bennett. Though its length is but 112 miles, it ranks high as an engineering achieve-

[1] *Engineering Magazine*, July 1903.

ment; possibly it was the most difficult bit of railway work ever performed. While clearing the trail for the track the navvies had to collect about 2000 dead horses into heaps and burn them with kerosene. Parts of the railway cost £50,000 a mile, the total expenditure reaching £1,000,000. So much needed was the road, however, that the first two years' running showed profits of £400,000; and shares which at one time had been going begging at 6½ dollars sold at 750 dollars apiece!

The track-builder is hard at work in other parts of Alaska. From Nome to Anvil Creek a five-mile line has been laid, "The Wild Goose Road," which in spite of its title has also proved a very good dividend earner. Seward Peninsula, on which Nome, a city of 25,000 inhabitants, is built, will shortly be gridironed by railways leading to and from the principal gold-mines, and forming the western feeders of a main trans-Alaskan system. In 1902 a track 82 miles long stretched from West Dawson to Stewart River, from which point to the Lakes the iron horse will probably soon be running. A railway has also been planned from Valdez, the most northerly ice-free port of Alaska, to Tanana on the Yukon, 430 miles away; and, more ambitious still, a great artery running southwards to join the Canadian trans-continental metals. When these schemes are completed it will be possible to travel continuously from Ottawa or New York to Nome, and on to the westernmost point of Alaska, whence a submarine tunnel under

the Behring Straits would provide a still longer run of several thousand miles to Paris.

Alaska may be cold, mosquito infested, fly-bitten, but she is well worth the £1,430,000 paid by the United States to Russia in 1867. A great future lies before her, one in which the gold industry may eventually recede into the background. Yet the day when George Carmack lit his camp fire, burnt away the moss, and discovered the rich gravel, is that from which the new era will be dated. As California and Australia were "boomed" by their gold rushes, and have since gained the larger part of their wealth from agricultural and grazing pursuits, so may the Yukon district be known to our descendants as one of the great wheat and timber-producing countries of the world.

CHAPTER VIII

DIAMOND MINING

The high estimation in which the Diamond has always been held—Mythical properties—Actual properties—Its value as compared with that of the Ruby—Diamond-cutting at Amsterdam—The Carat—Varieties of Diamond—India the earliest source of diamonds—Brazil a rival—Minas Geräes—Bahia—An observant shepherd—South African finds—A child's toy leads to the discovery of the Kimberley fields—The diamond "pipe"—Early days in Kimberley—Water invades the mines—The Illicit Diamond Buyer—"De Beers, Limited"—How the Blue Earth is disintegrated—The Pulsator—Kaffir labourers—The Compound—Work below ground—Diamond market controlled by De Beers—Value of Kimberley production—Kimberley in the War—Historic Diamonds—The Great Mogul—The Koh-i-nur—The Pitt—The Orloff—The Cullinan.

ROUND no substance in the world has romance woven itself more thickly than round the Diamond. The mere mention of this precious stone, "The Unconquerable," conjures up thoughts of royal jewels; of glittering assemblies where the rich vie with one another in the splendour of their ornaments; of the marvellous "Arabian Nights"; of Sinbad, Roc-borne into the valley where riches gleamed on every side; of the battles and struggles from which an historic jewel has emerged, to be lost, maybe, in obscurity. The diamond has taken such a hold on the popular imagination that, were the stories collected which have the fortunes of this precious stone as their theme, a small library would be the result. No

wonder, then, that ignorant folk have attributed to it many curious properties. In his "Natural History" Pliny writes: "The most valuable thing on earth is the diamond, known only to kings, and by them imperfectly. It is engendered in the purest gold only. Six different kinds are known; among these the Indian and Arabian, of such indomitable, unspeakable hardness that when laid on the anvil it gives the blow back in such force as to shiver the hammer and anvil to pieces. It can also resist fire, for it is incapable of being burnt. This superiority over steel and fire is subdued by goat's blood, in which it must be soaked when the blood is fresh and warm; then only when the hammer is wielded with such force as to break both it and the anvil will it yield. Only a god could have communicated such a valuable secret to mankind. When at last it yields by means of goat's blood, it falls into pieces so small that they can scarcely be seen."[1]

Behind these curious ideas there is a modicum of truth. Exceeding hardness is the most peculiar quality of the diamond, which can be scratched by no other substance, while it will make its mark on any body over which it is drawn. As regards its unbreakableness, we can only say that many a fine gem has been spoilt by the anvil-and-hammer test; and, so far as its heat-resisting properties are concerned, a diamond soon crumbles to ash if submitted to the temperature of the electric arc. Its com-

[1] vol. xxxvii. 15.

bustibility was first established in 1694, by some Florentines who directed on some small specimens the concentrated heat of very powerful burning-glasses. Later scientific research has clearly established the chemical character of the stone as pure carbon, a cousin of coal, which is consequently termed "black diamonds."

The extreme hardness of the diamond has made it an extremely useful ally to the geologist and engineer, who arm with it the tip of the circular hollow boring tool which eats its way through thousands of feet of the toughest rock before any replacement of the stones becomes necessary. (?) In a more humble way the glazier uses a tiny splinter of diamond mounted in metal to cleave the surface of glass.

This very property militated for centuries against the estimation in which the diamond is now held. Until its surface has been shaped into those wonderful facets which sparkle with refracted light the gem "is not much to look at." Only after Ludwig van Berquen discovered, in 1476, the method of polishing and grinding it by means of its own dust, did the diamond step into the foremost place which it now occupies among jewels—not that it is the most valuable weight for weight, since the *Oriental ruby far transcends it in this respect.*

Amsterdam is the great centre of diamond cutting and polishing. That town contains over sixty factories. Every diamond passes through three processes before

it is fit for sale as a jewel, viz. *splitting*, performed quickly by very skilful workmen with a diamond knife; *cutting* off the sharp angles in a similar manner; and *polishing* by machinery. A "brilliant" is given fifty-eight facets, a "rose" twenty-four, the workman pressing it against a wheel coated with oil and diamond dust. All three processes demand great care, for a false stroke might reduce the value of a stone to but a fraction of its original worth.

The word carat, signifying a standard of weight for precious stones, will be used so frequently in the following pages that a few words about it are necessary. *Carat* is probably derived from the name of an African bean, which, when dried, is very consistent in its weight, and therefore was employed in remote times by African gold merchants as their standard. The English ounce Troy is equivalent to 151½ carats; so that a single English carat equals about 3.174 grains. In foreign countries the weight varies from 105 milligrams in Spain, to 206.13 milligrams in Vienna. For our purpose the English carat is always used.

In its purest condition the diamond is quite colourless and transparent. If slightly tinted with yellow, green, blue, red, or brown, its value decreases, but deeply coloured gems are very highly prized. From Borneo come black diamonds of great beauty and such hardness that ordinary diamond dust will not polish them, and the adage

"diamond cuts diamond" holds true only if their own dust be used for the purpose.

For many years India was practically the sole source of diamonds. The eastern side of the Deccan, Madras, and the country round Nagpore, have yielded most of the finest Indian specimens, including the individual jewels which have each a romantic history of its own — The Great Mogul, The Koh-i-nur, The Pitt, The Nizam, The Great Table, The Orloff. Most of these have been won from alluvial deposits by poor miners of a very low caste working for the princes of the land. Golconda, a name associated with the diamond, is an ancient fortress to which the miners brought their finds, to receive some trifling reward in return.

Presently a rival country appeared. In 1727 a Brazilian, Bernardino Lobo, who had seen rough diamonds in India, was struck by the resemblance between these and little hard stones which the gold-diggers of Minas-Geräes, Brazil, occasionally found and used as counters for card-playing. He took a number of them to Portugal for sale, and their valuable nature was established. The European merchants, frightened lest the new discovery should prejudice their trade in Indian gems, industriously spread the report that the Brazilian specimens were only the refuse of Indian stones imported into Brazil for subsequent export. In reply the Portugese sent their gems to India, where they were labelled as Indian stones, and obtained

Digging up and screening the Kimberley streets for diamonds.

Indian prices. In two centuries Minas-Geräes produced £9,000,000 worth of diamonds. "The discovery of these precious stones," writes a great authority,[1] "in 1746 proved a great curse to the poor inhabitants on the banks of the diamond rivers. Scarcely had the news of the discovery reached the Government ere they tried to secure the riches of these rivers for the Crown. To effect this the inhabitants were driven away from their homes to wild, far-away places, and deprived of their little possessions; nature herself seemed to take part against them, for a dreadful drought, succeeded by a violent earthquake, increased their distress. Many of them perished, but those who lived to return were benevolently reinstated in their rightful possessions. Strange to say, on their return the earth seemed strewn with diamonds. After a heavy shower the children would find gold in the streets and in the brooks which traversed them, and would often take home three or four carats of diamonds. One negro found a diamond at the root of a vegetable in his garden. Poultry, in picking up their food, swallowed diamonds, so that their viscera required searching before being disposed of."

Attention was presently diverted from Minas-Geräes to the rich diamond-fields of Bahia, the old capital of Brazil. A Minas-Geräes negro, employed as a shepherd, noticing the similarity of the soil to that of his native place, searched the sand

[1] Mr. E. Streeter in "Precious Stones and Gems."

for precious stones and soon amassed 700 carats, which he took for sale to a distant city. Such wealth led to suspicion; and the negro was arrested and returned to his master, who had him watched, and learnt his secret. Before a twelvemonth was out, 25,000 people had flocked to Bahia, causing a panic in Minas-Geräes. Business there ceased, and the price of diamonds dwindled to one-half.

But Bahia's evil day arrived also, when the precious stone was first found, in 1868, in South Africa, henceforward the chief source of the world's supply.

The story of the wonderful Kimberley deposits begins with the action of a little Boer child, which amused itself by collecting pebbles from the river. One of these was so bright that it caught the eye of the child's mother, who took it indoors and showed it some time afterwards to a neighbouring farmer, Schalk van Niekirk. He, not knowing its true character, but thinking that it might have some value, offered to buy it: the woman laughingly said he was welcome to have it for nothing. Niekirk in turn submitted the stone to an English trader, Mr. J. O'Reilly, who offered to take it down to the coast and let the experts have a look at it: he to share any profits with the owner. O'Reilly, while passing through Colesberg, cut his initials with the stone on one of the hotel windows, and pronounced that he had got a diamond; but the people present were so incredulous that one of them took the thing and

threw it into the street, whence it was recovered only after a long search. At Grahamstown scientific tests revealed a genuine diamond. The stone, which weighed $21\frac{3}{16}$ carats, was sent to the Universal Exhibition in Paris, and afterwards found a purchaser for the sum of £500. We may only hope that the poor Dutch "vrow" never got to know the full history of the pebble which she had so light-heartedly given away.

This stone was discovered at Hopetown on the Orange River, in the district named Griqualand West. Many seekers soon began to turn over the veldt's surface, and to paddle in the Vaal River. An organised party under Mr. J. B. Robinson established themselves at Hebron, and systematically set to work to trace the stray stones to their origin, which was ultimately established near Kimberley in the dry diggings known as Du Toit's Pan, De Beers, Bultfontein, and Wesselton.

But this happened by accident. A farmer, named Van Wyk, was surprised to find diamonds embedded in the clay of which his house walls were built. Arguing that the place from which the clay had come might reasonably be expected to yield more stones, he began to dig, and so opened the famous Du Toit's Pan, fourteen miles south of the Vaal River.

The discovery of the diamondiferous nature of the Du Toit's Pan caused an immediate rush to the farm, now surrounded by a suburb of Kim-

berley, a town 650 miles north of Cape Town, supplied with all the comforts and luxuries of life. In Kimberley itself are the Kimberley and De Beers mines; the Du Toit's Pan and Bultfontein mines lie two miles south; and the Premier Mine (formerly Wesselton) is three miles to the south-east.

Geologically, the diamond mines are unique. Volcanic action has burst open the overlying quartz, shale, and igneous rock, and squirted up a "chimney" of diamondiferous rock, called blue-earth, though it is extremely hard. The chimneys, or pipes, are roughly elliptical or circular in section, their area varying at different depths. Some are thousands of feet across. How far down they reach is uncertain; very probably they extend to the fiery core of the earth. Some pipes are absolutely barren of diamonds; but those named above have proved themselves so rich that they now supply nine-tenths of the world's annual yield, and completely control the market value of diamonds.

In 1872 miners began to peg out claims in the Kimberley pan, thirty feet square, and each man dug when he felt so disposed. Between the claims ran roadways for the purpose of transporting the dirt. After a very short time it became evident that the road-ways and also the less energetically mined claims would prove a danger to the workers on claims which had been sunk to a considerable depth. Every now and then there was a landslip, burying tools, machinery, and sometimes human beings.

This resulted in endless lawsuits, the one party asking compensation for the entombment of his property, the other seeking damages for the undercutting of his higher ground.

As the general level of the excavation sank, the difficulty of removing the "earth" increased; and, the roadways being useless, platforms were established on the rim of the crater to which buckets could be transported on wire ropes. This got over the trouble to a certain extent; but when water appeared in large quantities the miners were confronted with an extremely awkward problem. It was at once nobody's and everybody's business to pump out the intruder—which distributed itself impartially among the claims—and, as is usual in such a case, nobody took the matter in hand. The workings fell in, and to-day there is a crater 650 feet deep, which, as Mr. Stafford Ransome remarks,[1] is probably the largest open hole ever made by man.

During the claim-working days the Kaffir labourers pilfered stones in great quantities and sold them to that obnoxious individual, the Illicit Diamond Buyer, known for short as "I.D.B." It is said that at least half of the diamonds found were thus disposed of; so that mining, which otherwise would have been profitable, soon proved a dismal failure.

The individual miner therefore sold his rights to syndicates or small companies; these in turn amalgamated into large companies, to be finally

[1] "The Engineer in South Africa," p. 248.

all swallowed up by one gigantic concern called the "De Beers Company," which controls the industry to an extent unparalleled in other branches of mining.

At the De Beers, Kimberley, and Bultfontein mines the blue-ground is worked by deep shafts driven down through the rock outside the pipe. The Premier mine has already reached the stage when open mining ceases to be advisable; and it too will soon have its shafts. About the process of getting out the diamondiferous rock little need be said, as it resembles coal-mining in most particulars. We may notice, however, that, owing to the huge capital possessed by the Company, every improvement in machinery is eagerly adopted. Out-of-date tackle soon finds its way to the scrap heap, which to the uninitiated eye might suggest a terrible waste of good stuff. The shafts are so deep—2000 feet and more in some cases—that high-speed winding becomes important. Skips fly up and down with 4-ton loads at nearly twenty-five miles an hour, and automatically discharge their contents into the head gear bins, from which they pass down shoots to the ground level.

The method of separating the diamonds from their matrix is most interesting. Fortunately for the proprietors, blue-ground rapidly disintegrates when exposed to the action of heat, cold, and water. So before introduction to the crushing mills, the material is spread a foot deep over rectangular

areas—known as "floors"—measuring 400 by 200 yards, previously stripped of all grass, bush, or loose stones. A harrow is occasionally drawn backwards and forwards over the rock by steam engines to aid the crumbling, water being squirted freely if the weather remains dry.

At the end of a year "the ground," now fit for crushing, is washed, and churned in a mill which separates the heavier from the lighter portions. The "concentrates" are taken to the pulsator, an automatic diamond-finder, and from it "are allowed to drop by means of a carefully regulated feed on to the highest of a series of inclined trays, arranged in the form of a shallow ramp or staircase. These trays have a pulsating, or vertically vibrating movement, which gives its name to the machine. The upper surfaces of these trays are covered with a thickish layer of Stauffer's lubricant, which has for its object the retention of any diamonds that may come into contact with it."[1]

The important discovery of sorting diamonds by adhesion arose from noticing that the stones stuck to any grease that fell into the old-fashioned washing pans. A test was made with very small stones aggregating 6601 carats, out of which only 111 carats escaped the grease. With coarser material only 40¼ out of 19,031 carats got away; which proved that the larger stones are less likely to be lost than the smaller. Apart from its effectiveness,

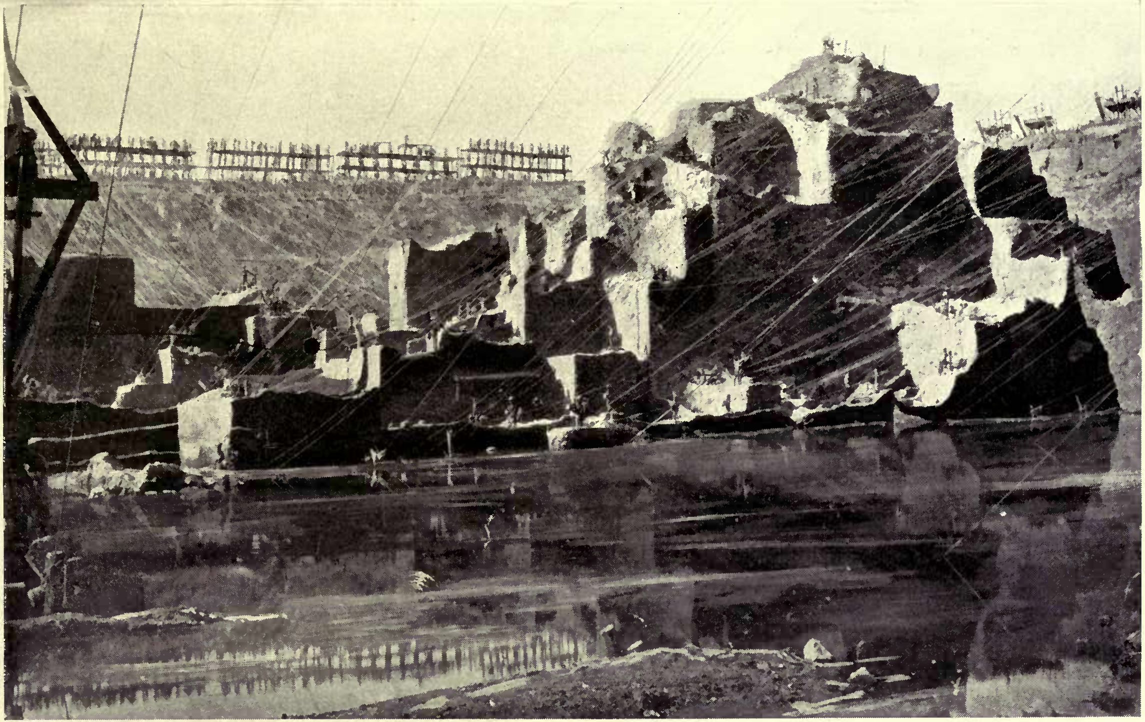
[1] "The Engineer in South Africa," p. 255.

this system does away with native labour and the need for a great amount of supervision.

The grease and its adherents are scraped off the trays and consigned to a melting-pot, which quickly sends the stones and the rubbish to the bottom. The grease runs off, leaving the deposit free for inspection and sorting, done by highly trained experts. The stones are then washed in sulphuric acid and sent to the head office in Kimberley, to be more perfectly classified, and stored ready for sale. The sorters here "work in a carefully locked office, to which the visitor is only admitted on production of a pass, and after being scrutinised suspiciously through a little grille in the door. And when he gets inside this Holy of Holies, he finds himself railed off from the counters on which the piles of gems are being sorted, in case the sight of such vast riches should cause his cupidity to get the better of his morality."[1]

About 15,000 Kaffirs and 2500 whites are employed in the mines. The nature of their work necessitates a strict guard being set on the Kaffirs, for they are the expertest of thieves. To let them go in and out of the mines would mean the loss of many valuable stones; they are therefore obliged to sign a contract for a period of at least six months' work, during which no egress from the mine compound is permitted. Once in, always in, till their term has been completed. Not that they fare badly,

[1] "The Engineer in South Africa," p. 257.



A Kimberley Mine in the early days. The various claims have been worked to different depths, giving the field

since stores in the compound furnish anything they may wish to buy. They have clean, neat houses, a hospital, swimming baths, and a chapel where a native preacher holds forth on Sundays, helped by an interpreter who translates his dialect into one more readily understood by the audience. It is to the credit of the De Beers Company that intoxicants of all kinds are rigorously forbidden on the premises—a great contrast to the drink-sodden compounds of the Rand before the war.

With no less than £4,000,000 worth of diamonds lying in the disintegrating blue-ground, some theft occurs in spite of the utmost vigilance. Guards are always patrolling the boundary, strongly fenced with barbed wire entanglements. At night strong arc lamps light up the floors, so that any would-be pilferer may be seen by the watch. "The Kimberley compounds are covered with a wire netting to prevent the throwing out of diamonds, it being found that old tins and similar articles were utilised for this purpose, on the chance of picking them up outside the walls after dismissal."[1]

The amount of material raised from the diamond mines is astonishing. "Up to May 1, 1883, 10,325,989 loads of sixteen cubic feet each had been removed from the Kimberley mine alone, equivalent to 3,824,440 cubic yards of solid rock, at a cost of £1,545,358. In 1883, 1,688,914 loads of reef were removed; in 1884, 711,033

[1] *Cassier's Magazine.*

loads from this one mine.[1] . . . An idea of the work done in the De Beers mine in one fortnight may be obtained from the following figures: During the first two weeks of November 1897, there were used $8\frac{3}{4}$ tons of dynamite, 65,100 feet of fuse (equal to $12\frac{1}{3}$ miles), and 32,500 blasting-caps, and during the previous month the record hoisting was made of 182,040 loads, or 145,632 tons, through one shaft, and from the 1200 foot level."[2]

The "boys" work below ground in gangs of thirty or forty, under the direction of a white miner, or boss. The mines being well lit and ventilated, and the drives of large size, their work is not unpleasant; but there is one thing which they fear, as a coal-miner fears fire-damp—a mud-rush. The huge open excavations made in the early days form natural reservoirs for spring or rain water, which, together with fine particles of matter, sinks down through cracks in the form of a thick paste. If this is "tapped" it rushes with terrific force and speed through the galleries, carrying trucks, rails, and timbers before it irresistibly. Sometimes there is loss of life; and the authorities have now instituted a system of draining the overlying stratum by means of pumps, so as to prevent the accumulation of water. From the De Beers mine 5000 gallons per hour are pumped; from the Kimberley double that quantity; and the gradual

[1] *Cassier's Magazine.*

[2] *Cassier's Magazine.*

decrease in the amount proves that the method is efficacious.

Reference has already been made to the control exercised by the De Beers Syndicate over the diamond markets of the world. It has been shown by statistics that about four and a-half million pounds sterling are spent yearly on this class of precious stone. If all the year's product were suddenly offered for sale, there would probably follow a "slump," or general fall in prices. Then, again, the fashion changes from time to time; now, single big brilliants, costing hundreds of pounds each, are in demand; now much smaller stones set closely together in large numbers; while in "bad times" people will not invest in very costly jewels, but there is a considerable public who do not mind the expenditure of a few pounds on cheaper stuff.

So the De Beers people carefully regulate the supply to meet the demand, keeping stored away under lock and key huge quantities—tons, in fact—of jewels, and waiting for the moment when any one kind may be needed. If the reserve becomes unwieldy, they simply decrease the number of their employés. Hence the Syndicate has a unique, and at present unchallenged position,—an ideal one from the seller's point of view. The nearest approach to a rival is the Jagersfontein mine, notable for having produced what is probably the second largest diamond ever mined by man,—a monster of 971 carats, or about six and a half ounces! It is a flat,

almost rectangular stone, about two inches long, and from seven-eighth inch to one and a half inches thick; of a blue-white tinge, of very fine colour, and of a value which cannot be computed.

By the end of 1904 the total value of diamonds exported from South Africa reached nearly £90,000,000. How much this amount will be increased before the mines stop working we cannot say. The blue-ground may prove poor in stones as the mining proceeds; or the depth to which it can be profitably worked may turn out to be more limited than at present appears probable; or, and this is the most uncertain element of all to reckon with, mines of even greater richness may be discovered elsewhere, in the unexplored parts of Asia, Australia, or America. For all we know wild animals may be browsing on land far away in the Pamirs or Andes which in time will see the rise of diamond cities even greater than Kimberley.

This chapter would not be complete without a short reference to the siege of "Diamondopolis" during the war. From October 1899 till February 15, 1900, it stubbornly resisted all efforts of the Boers to reduce it. Large numbers of the inhabitants took refuge from shells in the old workings of the mines. The De Beers Company, headed by Mr. Cecil Rhodes, did its utmost to relieve the distress caused by scarcity and bad quality of provisions; and also took an active part in the fighting. Their workshop staff, under the supervision of Mr.

Labram, built the big gun named "Long Cecil," as a reply to the "Long Toms" of the besieging force; and with it hurled shells into the Boer trenches.

Before quitting the fascinating subject of diamond-mining some historic stones may be fitly passed in rapid review.

The Great Mogul.—This magnificent stone was discovered about the middle of the seventeenth century. Its weight of nearly 800 carats places it next to the "Jagersfontein" and "Cullinan" jewels. Tavernier, a French traveller, was shown the jewel by its owner, Shah Jehan, at Agra, in 1665. "The first piece that Aked Khan—keeper of the king's jewels—placed in my hands was the great diamond, which is rose-cut, round, and very high on one side. On the lower edge there is a slight crack, and a little flaw in it. Its water is fine, and weighs 319½ *ratis*, which make 280 of our carat. . . . In the rough state it weighed 787½ carats. . . . It was Hortensio Borgis who cut it, for which he was also badly paid. When it was cut he was reproached for having spoilt the stone, which might have remained heavier, and instead of rewarding him for the work the King fined him 10,000 rupees, and would have taken more if he had possessed more."

After the sack of Delhi by the Persian, Nadir Shah, the stone disappears from history. Probably it was stolen during the sack, or at the death of Nadir, and split up into a number of smaller stones.

The Koh-i-nur.—The most romantic of all diamonds. Its early antecedents are unknown; but tradition mentions it as the property of a prince who lived in 57 B.C. Like the Great Mogul, it had a place in Shah Jehan's treasury, and subsequently in that of Aurung-Zeb. Nadir Shah, on entering Delhi, could not find the gem; until a woman betrayed the secret that the emperor wore it concealed in his turban. How could he get hold of it? Mr. Edwin Streeter thus tells the story: "He skilfully availed himself of a time-honoured Oriental custom, seldom omitted by princes of equal rank on state occasions. At the grand ceremony held a few days afterwards in Delhi, for the purpose of reinstating Mohammed (Emperor of Delhi) on the throne of his Tartar ancestors, Nadir suddenly took the opportunity of asking him to exchange turbans, in token of reconciliation, and in order to cement the eternal friendship that they had just sworn for each other. Taken completely aback by this sudden move, and lacking the leisure even for reflection, Mohammed found himself checkmated by his wily rival, and was fain, with as much grace as possible, to accept the insidious request. Indeed, the Persian conqueror left him no option, for he quickly removed his own national sheepskin head-dress, glittering with costly gems, and replaced it with the emperor's turban. Maintaining the proverbial self-command of Oriental potentates, Mohammed betrayed his surprise and chagrin by no outward sign, and so indifferent did

he seem to the exchange that for a moment Nadir began to fear he had been misled. Anxious to be relieved of his doubts, he hastily dismissed the Durbar with renewed assurances of friendship and devotion. Withdrawing to his tent he unfolded the turban, to discover, with selfish rapture, the long coveted stone. He hailed the sparkling gem with the exclamation 'Koh-i-Nur'! signifying in English, 'Mountain of light.'"

But possession brought misfortune to the possessor. Nadir bequeathed it to his son Rokh, who was overthrown by Aga Mohammed and tortured to reveal the hiding-place of the stone. All sorts of ghastly devices failed to extract the secret. Rokh, blinded and maimed, gave up the great ruby which Aurung-Zeb had worn in his crown; yet he clung to the diamond as to life itself. Before he died he gave it to Ahmed Shah, founder of the Durani Afghan Empire, as a reward for help against Mohammed.

From Ahmed it passed to his son Taimin; from him to his son Zaman, deposed and blinded by a brother, Shuja, who got hold of the stone by the merest accident. While in captivity Zaman concealed it in a crevice in his cell, and covered it with plaster. The plaster fell off; a glittering corner protruded and scratched a courtier's hand; and the jewel came into history once again. Shuja was in turn deposed by a younger brother, and withdrew to the court of Runjit-Singh, the "Lion of the

Punjab," who at first received him kindly, but later tried to extort his treasures from him, especially the Koh-i-nur, and at last succeeded. He wore it on all public occasions.

When the English, in 1840, took possession of the Lahore Treasury, the Koh-i-nur became the property of the East India Company, and was sent to England as a present to Queen Victoria. Its transference from East to West appears to have changed its power for evil into one for good, as it arrived during the early years of England's most glorious reign.

When it reached Europe it scaled $186\frac{1}{16}$ carats; subsequently reduced by re-cutting to $106\frac{1}{16}$ carats. And now it is preserved among the Royal Jewels at Windsor, a model in the jewel room of the Tower acting proxy for exhibition purposes.

The Pitt, or Regent.—Found in 1701 in the Parteal mines on the Kistna, by a slave, who concealed it in a hole made purposely in his leg. He escaped to the coast and gave it to a sea-captain on condition that he should transport him to a free country. The captain took the jewel, and threw the poor slave into the sea. Eventually it came into the hands of Thomas Pitt, who paid £20,000 for it, and afterwards sold it to the French Regent, the Duke of Orleans for £135,000. With the great profit Pitt restored the fortunes of his ancient house, which afterwards gave England two of her most distinguished statesmen. In 1791 it was valued at £480,000.

During 1792 it disappeared from the French Royal Treasury, but was recovered, and pawned to the Dutch Government by Napoleon to raise money. Afterwards redeemed, it found a last resting-place in the now disused crown of France.

The Orloff.—Said originally to have formed the eye of an idol in a temple in Brama at Srivangam; and to have been stolen by a French Grenadier, who sold it for £2000 to an English sea-captain. He in turn sold it for £12,000 to a Jew, who disposed of it to Prince Orloff, a courtier in the household of Catherine II. of Russia, for £90,000. Orloff gave it to Catherine; and it afterwards became the chief ornament of the Imperial sceptre.

The "Cullinan."—Discovered early in 1905 in the Premier Mine, Transvaal. The stone, which is by far the largest ever found, weighs 3032 carats, or nearly one and a-half lb. avoirdupois. It measures 4½ in. by 2¼ in. Its value is incalculable.

CHAPTER IX

THE STORY OF THE COMSTOCK LODE

Discovery of the Lode—Henry Comstock—Silver ore cast aside as worthless—An assay proves its true value—" Rush " to the mines—Difficulty of treating ore—Paul's reduction mill—The timbering of the mines—Litigation—Bonanza times—Mark Twain—The Sanitary Flour Sack—Extent of the mines—The overland telegraph—The new highroad—Its maintenance—Rivalry between stage drivers—Accidents—Depression—Labour troubles—Water inroads—The Sutro Tunnel—A marvellous engineering feat—Hardships of tunnel-driving—John W. Mackay—The "Virginia Consolidated"—Perseverance brings fortune—The Big Bonanza—Huge yields—Wild speculation—Scene in the mines—High temperatures—A sad contrast—The fate of the Comstock.

TO a few barren acres on the western slopes of the sterile Sierra Nevada belongs the honour of having yielded mankind a greater bulk of riches than any other area of equal size on the earth's surface. "The Great Comstock Lode" is synonymous, to those who know its history, with enormous fortunes, wild speculation, heroic struggles against adverse circumstances, Aladdin's cave realised, hopes disappointed, chagrin unfathomable, the lowest depths of commercial trickery, gigantic games of chance, marvellous feats of engineering, money spent like water, water inrushing like a flood, labour conducted under terrible conditions. All these ideas flash through the mind at the mere mention of the silver seam which for

twenty years was the cynosure of the world's money markets.

The Comstock Lode revealed itself very quietly. Just a decade after the discovery of gold in California, when men were penetrating the Sierra to seek new Eldorados, two miners, Patrick McLaughlin and Peter O'Riley by name, dug a water hole in a gulch of the Carson River Valley. The earth thrown out was a yellow sand, mingled with small lumps of quartz, and friable black rock, which they were unable to recognise as stuff of any value, and cast carelessly aside. However, with the instinct of the prospector, and from habit rather than with any definite hopes, they washed out a panful or two of the "dirt," and to their surprise and delight saw the welcome "colour." Again and again they washed; gold accumulated in their wallets; they were on the highroad to fortune. They had knocked at the doors of the Comstock's treasure-house, and found riches even on the scraper.

Notice this: that, while the great Nevada deposit is renowned chiefly for the silver it has produced, it was the intermingled gold which brought it to light. But for those superficial specks of gold the millions of tons of silver ore might have lain undiscovered for many years to come. Nature had, as it were, scattered a trail of recognisable metal to lead men into a branch of mining hitherto unpractised in the United States.

While McLaughlin and O'Riley were hard at work,

there stumbled on them one Henry Comstock, whose otherwise contemptible personality will go down to history because it gave its name to this wonderful mine. An ex-trapper and fur-trader, restless, yet lazy, he had wandered about for years, taking up a claim here and there, to soon quit it and resume his prospecting. One evening he chanced to find the two Irishmen cleaning-up their rocker for the last time before stopping work for the day. His practised eye took in the situation at a glance. With matchless effrontery he informed the lucky pair that they were trespassing on his land; and by sheer talking prevailed upon them to concede his claims! Thus it was that, though the true discoverers have been forgotten, the name of Comstock has survived.

Other prospectors soon arrived, and pegged out their lots, while McLaughlin and O'Riley opened up the pocket. They were much hindered by a seam of black rock which made its appearance at a depth of three or four feet, and increased in width as the trench deepened. The looser earth on each side yielded, however, sufficient gold to keep them at work.

Presently curious visitors began to carry off bits of the black rock, and in due course some specimens got into the hands of a Placerville assayer, whose test showed a value per ton of £600 in silver and £175 in gold; and the tidings spread that a lode of silver sulphurets had been struck on the eastern slope of Mount Davidson in Western Nevada.

Though silver mining was a new thing to the Californian miner, the Sierra passes became more and more thickly choked by a stream of fortune-hunters. "Rough-haired mustangs, gaunt mules, and sure-footed little 'burros' climbed the sierras loaded with stacks of blankets, bacon, flour, kettles, pans, shovels, and other articles of a miner's outfit. The ravines and brown hillsides were dotted with a restless swarm. Thin wreaths of smoke rose from hundreds of little camp-fires on the hills, and the sharp strokes of falling picks startled the lizards from their hiding places in the rocks."[1] California was on its way to grasp the treasures of Nevada, hitherto missed by the thousands of immigrants who had trampled them unawares in their haste to reach the gold deposits of the Sacramento River.

This happened in the "fall" of 1859. Not much prospecting could be done that year; and the early arrivals spent a cheerless, hard winter waiting for the time when work might begin in earnest. Fierce whirlwinds howled through the gorges and down the sides of Mount Davidson, unroofing the miserable huts, and sweeping off flimsy tents. The occupants swore; and erected other dwellings. What were the cold, hunger, and fatigue of to-day by comparison with the coming riches of to-morrow?

Meanwhile the exhibition of silver bars in San Francisco had rekindled the fever of 1849 and 1850. "The treasures of Potosi, the ransom of

[1] "Monograph of the United States Geological Survey."

Montezuma, the deep-laden galleons of Spain, and a host of vague memories were awakened by the sight of these masses of bullion. The fever spread rapidly: merchants closed their counting-houses and clerks left their desks; sailors deserted their ships and mechanics their workshops; the ranchmen from the plains and the restless swarm of gold-placer miners swelled the migration not unlike the train of children drawn on by the entrancing notes of the piper of Hamelin. How to reach the silver ledges was the absorbing thought; far beyond the sierras the riches of their dreams appeared before them; and neither inexperience nor poverty could deter such passionate pilgrims from joining the odd troop which began its march over the mountains while the passes were still impassable."[1]

So, early in 1860, every boat which left San Francisco for Sacramento was packed with miners and their outfits. From the latter town the army pushed up the old emigrant trail to Placerville, and thence over the Johnson Pass to the valley of the Carson. Snow blockaded the broken track. Hundreds of tons of freight accumulated in the Californian town, waiting until teams could be found to carry it through the Sierra. At last, in March, the caravans began to pour into the mining camp on Mount Davidson, and soon crystallised into Virginia City, where for months vice and rowdyism flourished unchecked. The true work-

[1] "Monograph of the United States Geological Survey."

ing miners were far outnumbered by the floating scum of California, who followed, jackal-wise, the movements of the metal seekers. Volunteers for the Indian War, demoralised by guerilla warfare, flocked in, lolled at the gambling-tables, and swaggered about the streets, the terror of the more peaceful portion of the community.

A mining difficulty soon arose. Ore could be raised with ease; but the extraction of the precious metal it contained was a serious problem. Transportation to San Francisco for treatment ate up most of the profits; while the lack of fuel made reduction on the spot almost an impossibility. However, Almorin B. Paul, an enterprising mill-owner of the city of Nevada, saw his opportunity, raised the necessary capital, and entered into contracts with various mines to smelt all their ore at a fixed rate per ton; and, what was more, to commence smelting within sixty days of the signature of the contract. Every pound of material used in the machinery had to be brought from San Francisco, partly by water, partly overland, along a track where the waggons sank to their axles in the mire, and the mules, urged on by blows and curses, had to exert all their power to keep their cumbersome freights in motion. The cost of transportation exceeded the actual cost of the machinery; the lumber used in the reduction-mills touched fabulous prices. Yet Mr. Paul was undismayed; and on the last day allowed by the contract the

"Washoe Gold & Silver Mining Company, No. 1," began to crush ore. So successful did the first crushings prove that mine-owners who had previously ridiculed the project gladly sent their ore to the mills, and Mr. Paul entered upon the reward he so justly deserved.

Difficulty number two now appeared. As the lode descended it grew steadily broader, until at a depth of 175 feet it was 65 feet wide. Such dimensions being without precedent, the miners did not know how to proceed. To leave pillars of ore to support the roof was of no avail with a roof that crumbled in. Spliced timbers bent and broke. So that the owners at last found themselves surrounded by riches which they could not carry away except by risking their lives in doing so.

Expert advice was sought. Mr. Philip Deidesheimer, manager of a Georgetown quartz mine, came, examined, and designed a system of timbering which exactly suited the particular needs of the Comstock Lode. To refer again to the authority already quoted: "This was to frame timbers together in rectangular sets, each set being composed of a square base, placed horizontally, formed of four timbers, sills, and cross-pieces from 4 to 6 feet long, surmounted at the corners by four posts from 6 to 7 feet high, and capped by a framework similar to the base. The cap-pieces forming the top of any set were at the same time the sills or base of the next set above. These sets could

readily be extended to any required height and over any given area, forming a series of horizontal floors, built up from the bottom sets like the successive storeys of a house. The spaces between the timbers were filled with waste rock or with wooden braces, forming a solid cube whenever the maximum degree of firmness was desired."

So the delving was continued to two, three, four hundred feet. The Gould & Curry, Gold Hill, and Ophir mines poured out their riches. For a couple of miles north and south ran the lode, fifty to eighty feet wide between its walls of solid rock. Over so rich a prey there was, as may easily be understood, plenty of quarrelling; and from 1860 to 1863 the litigation arising out of disputes as to limits, water rights, validity of claims, &c., choked the local courts, where many an advocate, hitherto unknown, made a fortune out of his fees. Into the intricacies of these actions-at-law there is no inducement to enter: for only to the persons immediately concerned could they possibly afford much interest. They serve, however, to show that where a number of people settle down on a rich spoil they can no more dwell together in unity than a number of vultures engaged on rending the same carcass.

The years 1863 and 1864 were the "bonanza" —*i.e.* fair-weather—times. Mark Twain has drawn with his facile pen a remarkable picture of how at this period men made each other presents of "feet" in mines just as in other localities one might

offer a friend an apple or a pinch of snuff: and how all sorts of tricks were resorted to by those who wished to turn a worthless shaft into a saleable property—"salting" with genuine ore or even melted silver coins being included among these devices. It may come as news to admirers of the novelist who have not read his "Roughing It," that Mr. Twain himself took a hand at mining; and in conjunction with two friends struck a "blind lead" which crossed the Wide West vein at an angle, pegged out claims, and was a potential millionaire. By an unfortunate misunderstanding all three partners absented themselves from the claims, each thinking that the other two would do the work necessary to keep the property in their possession. When, at the end of nine days, they became aware of their danger, two of them hurried back, to find that they were just a few minutes too late, and that eager onlookers had used their rights to re-locate and "jump" the claims. "We would have been millionaires," he says, "if we had only worked with pick and spade one little day in our property, and so secured our ownership! . . . I can always have it to say that I was absolutely and unquestionably worth a million dollars, once, for ten days."

It was during this first "boom" that the Sanitary Flour Sack went its round of the mining towns of the Comstock district. The great Civil War had broken out, with the terrible suffering inseparable from such conflicts; and the hearts of the citizens

went forth to the wounded lying on distant battlefields. A Sanitary Fund had therefore been set on foot for the relief of the sufferers; and Nevada, anxious to do her share, raised money in many ingenious ways. At Austin a sack of flour was put up to auction—the proceeds to go to the fund—and knocked down at 5300 dollars. It then passed on to Silver City, which bid 1800 dollars; to Gold Hill, where the purchaser had to pay 6587½ dollars; to Virginia City, which advanced to 13,515 dollars. From Nevada willing hands carried it down to Carson; thence over the Sierras to California. It finally found a haven in San Francisco, but not until it had enriched the fund by £30,000 sterling!

This was the miners' play. They could also work hard. At the close of 1862 no fewer than forty companies had erected houses of some sort over their shafts, and in several instances steam machinery was already installed for hoisting and pumping. Seen from the top of Mount Davidson, the heaps of *débris* raised appeared like ant-hills gradually growing from day to day. Some hills were almost deserted, but all round the Mexican, California, Gould & Curry, Potosi and Chollar claims, men, horses, mules, and oxen swarmed. The streets were blocked by vehicles hurrying this way and that. Below the surface an army of sweating miners burrowed along the lode, which, like the Rand gold reefs, sank at a considerable angle to the perpendicular. Every day they advanced a few more feet,

propping up the dangerous roof with a huge skeleton of timber, each balk of which had but a short time before been braving the strong winds of the Sierra. The haphazard methods of 1860 gave place to a well ordered plan of working by cross-cuts, galleries, and winzes. In 1862 the Gould & Curry had over five and a-half miles of "dismal drifts and tunnels"; and the Comstock as a whole could boast thirty miles of subterranean streets, thronged by 6000 workers. By 1866 the borings had increased to fifty-seven miles, which represents but a fifth part of the ultimate total in after years.

Nevada produced £5,000,000 worth of bullion in 1863, the year of "nabobs," who flew up and down the ladder of fortune like so many shuttlecocks. The Gould & Curry mine, bought from its original owners for an old horse, a bottle of whisky, some blankets, and 2500 dollars in cash, was four years after the purchase valued at 7,600,000 dollars. A long list of fortunes thus lost and won might easily be made, for the history of the Comstock is but a record of Peter impoverished and Paul raised to millionairedom.

Two great engineering feats mark the earlier years of the silver-mine. The first, the telegraph line carried from Omaha over the Rockies to Fort Churchill, where it met a second line extending from San Francisco through the Sierra Nevada. The Americans, with characteristic energy, put up 570 miles of this electric thread in *four months*—a

record all the more remarkable in view of the fact that its route lay through the dreary wastes of the great Desert. Thus in 1861 Virginia City, the nerve-centre of wild speculation, was in touch with the civilisation of two coasts. The news of a big "find" on the lode became common property in San Francisco and New York almost before the discoverers had realised their good fortune.

The second service rendered by the engineer was that of making a fine highroad across the Sierras *via* the Johnson Pass. "During 1861 and 1862 toll grants were obtained, and a small army of labourers was at work on both slopes of the range from foot to summit. The steepest grades were cut down and smoothed; gullies and ruts were filled with compact layers of broken stones and loam; bordering rocks were blasted away or rolled aside; and the narrow, dangerous, wretched trail, scarcely fit for the passage of sure-footed pack-mules, became a broad, compact, well-graded highway, which might fairly be likened to an old Roman road. The stage-coach ride across the mountains, which had hitherto been a 'torture,' became a pleasure. . . . The turning-points of the road were broad platforms built up from the hill-sides with outward curving base-walls of well-joined rocks. On the level surface of these bastions an eight-mule team could turn without slacking their traces, and loaded waggons could pass one another at all points on the road without difficulty. When snowdrifts blocked the

passage in winter, a well-equipped party of men and horses sallied from every station and cleared the way with extraordinary despatch, while watering carts, passing from station to station, laid the dust in summer, so that the road was like a well-kept avenue in a mountain park."[1]

Great as the expense of making the road was, the builders soon reaped a harvest. Every vehicle paid a toll; and at times the mule teams stretched in a continuous procession for miles. Rivalry ran high among the stage-drivers, for whom a fresh "record" ranked above the safe delivery of their charges. Special coaches, with many relays of horses, covered the 130 miles between Virginia City and Sacramento in 12½ hours, a speed of travel which fairly eclipses the performances of the Bath Road "cracks." Every now and then this time-cutting led to a serious accident, taken in good part by any survivors. "When a Johnson's Pass stage toppled over the brink of an embankment, and the falling wreck was stayed by chance in the spreading arms of a large pine tree, the bruised passengers looked down upon the bottom of the abyss, 1000 feet below, and congratulated themselves on their good fortune without censuring the coachman even in thought." The excitement of travel, arising from the possibility of such incidents being repeated, was increased by the frequent hold-up of a coach by masked desperadoes, who turned out the passengers and stood them in a row, with their hands

[1] "Monograph of U.S. Geological Survey."

over their heads, while their persons and the coach were searched thoroughly for booty. Have we not read of these incidents in the pages of Bret Harte?

With the latter half of 1864 came the inevitable fall in the inflated prices of mining shares. Some of the most valuable stock tumbled to one-fifth of the previous year's quotations; dragging down the shareholders in "wild cat" schemes to absolute ruin. The need for severe retrenchment of working expenses became imperative, and the mine directors naturally lowered wages, which in the "boom" times had been fixed at four dollars a day. The miners, unable to see that labour as well as capital must take its share in a general depression, soon showed their teeth. John Trembath, the stalwart Cornish foreman of the Uncle Sam mine, being suspected of sympathy with the proprietors, was seized while in one of the lower levels, bound hand and foot, and lashed to the hoisting cable of the shaft. His captors then tied to him a label with the words, "Dump this waste dirt from Cornwall," and thus mummified, the wretched man was lowered and hoisted twice. From this rough horseplay the miners passed to organised processions, and the formation of a "Miner's League," which pledged every member never to give a day's work for less than four dollars in gold and silver. The League wilted under the economic effects of continued depression, and practically went to pieces within a year. It revived, however, with the return of prosperity to the Comstock, and is still a power in the district.

With these huge excavations being cut through a hillside, water, the bugbear of mining, had by 1864 become a serious hindrance to progress, notably in the case of the Ophir mine. At the higher levels horizontal shafts, or adits, were driven through the wall to the open air, and these served for a time to drain off the water. But when the shafts reached a depth of a thousand feet or more pumping became the only method of clearing the mines, unless a great combined effort were made and a main drainage tunnel driven right through the hill at a level which would tap the whole lode nearly 2000 feet below the surface.

In 1865, Mr. Adolph Sutro formed a company to construct a tunnel extending from the foot-hills of the Carson Valley into the lode, a distance of nearly four miles. He urged that all mines sooner or later reach a depth where the constantly increasing cost of mining exceeds the yield, and that the Comstock lode would, before the lapse of many years, provided no other means for draining and working the mines were adopted, become practically valueless and deprive one hundred thousand people of their occupation and means of subsistence. Such works had already been carried out successfully and profitably in the Claustal mines of the Harz Mountains, where a ten-mile tunnel entered the 900-foot level; at Freiburg, with its eight-mile tunnel; and at Schemnitz, where the Emperor Joseph adit burrows for nine miles.

In 1865 the companies interested signed a contract whereby they agreed to pay the Tunnel company a royalty of two dollars per ton on all ore extracted from their mines, in return for the drainage and the privilege of transporting men, ore, waste rock, and materials through this back door at fixed rates. Scarcely had the contract been signed when some repented themselves, and, in order to back out of their agreement, stirred up formidable opposition to the scheme. Mr. Sutro was, however, a man of indomitable will. He overcame all difficulties, including that of raising capital, and in September 1871 commenced his attack on the hills.

Progress was at first sadly hampered by the inrush of water, and by the inefficiency of hand drilling, which advanced the borings only 5¼ feet a day even when things were going well. The engineers therefore had recourse to the imperfect power-drills of the time, to find them very costly and tedious implements to work with. Fortunately for the tunnel, the Burleigh drill appeared in 1874, and the rate of advance was quadrupled, though the dimensions of the working face had been increased to 9½ feet of height by 13 feet of width.

Mr. Eliot Lord has given the world, in the monograph already laid under contribution, so graphic a description of this great work that no apology is needed for reproducing it *in extenso*. "Sutro's untiring zeal kindled a like spirit in his co-workers. Changing shifts urged the drills on without ceasing;

skilled timberers followed up the attack on the breast and covered the heads of the assailants like shield-bearers. The hot rocks blown from the face of the heading hardly ceased rattling on the floor of the tunnel before they were thrown and shovelled into iron tramcars and borne away by mule trains. Lanterns bound to the shoulders of the mules threw straggling rays of light on the dark pathway; the dripping walls and roof reflected the beams through a myriad of water prisms, and streaks of mottled grey, green, and black rocks shone out at intervals with vivid distinctness, as if illuminated by lightning flashes. A foreground and background of utter blackness enclosed the moving cylinder of changing lights and shadows, a fitting framework to the weird picture. As the train neared the mouth of the tunnel it was seen first as a line of dancing lights, then the tinkle of collar-bells was faintly heard and the tramping of hoofs on the rock floor. The light specks swelled to clearly shining stars and then shrunk to red points in the glare of the sun rays, which transformed the roughly-timbered entrance into a white-pillared corridor. In this transfiguring light the eyes of the mules glowed like carbuncles, which shone in their dark setting till the animals, with quickened steps, passed through the gleaming archway into the sunlight. The dump at the mouth of the tunnel grew rapidly to the proportions of an artificial plateau raised above the surrounding valley slope; yet the speed of the electric currents which

exploded the blasts scarcely kept pace with the impatient anxiety of the tunnel owners to reach the lode when the extent of the great Consolidated Virginia Bonanza was reported; for every ton raised from the lode before the tunnel cut it was a loss to them of two dollars, as they thought. Urged on by zeal, pride, and natural covetousness, the miners cut their way indomitably towards their goal, though at every step gained the work grew more painful and dangerous. The temperature at the face of the heading had risen from 72° Fahrenheit at the close of the year 1873 to 83° during the two following years; though in the summer of 1875 two powerful Root blowers were constantly employed in forcing air into the tunnel. At the close of the year 1876 the indicated temperature was 90°, and on the first of January 1878 the men were working in a temperature of 96°. In spite of the air currents from the blowers the atmosphere before the end of the year 1876 had become almost unbearably foul as well as hot. The candles flickered with a dim light, and men often staggered back from their posts faint and sickened. Behind the workers were sections of treacherous ground—crumbling rock and swelling clay—which occasioned constant dread lest some day the overstrained props might give way and a falling mass crush the air pipes and block the passage. In such event the men might die for lack of air in the narrow tomb before they could cut their way through the barrier or be rescued by outside help.

This was not a fanciful peril, as it was averted more than once by the watchfulness and promptness of the miners in propping up sinking ground and piercing the fallen débris. During the months immediately preceding the junction with the Savage Mine works the heading was cut with almost passionate eagerness. The miners were then two miles from the nearest ventilating shaft, and the heat of their working chamber was fast growing too intense for human endurance. The pipe which supplied compressed air to the drills was opened at several points, and the blowers were worked to their utmost capacity; still the mercury rose from 98° F. on the 1st of March 1878 to 109° on the 22nd of April, and the temperature of the rock face of the heading increased from 110° to 114° during the same period. From the first day of May 1878, it was necessary to change the working force four times a day instead of three, as previously, and the men could only work during a small portion of the nominal hours of labour. Even the tough, wiry mules of the car train could hardly be driven up to the end of the tunnel, and sought for fresh air not less ardently than the men. Curses, blows, and kicks could scarcely force them away from the blower tube openings, and more than once a rationally obstinate mule thrust his head into the end of the canvas air-pipe, and was literally torn away by main strength, as the miners, when other means failed, tied his tail to the bodies of two other mules in his train and forced them to haul back their

companion, snorting viciously, and slipping with stiff legs over the wet floor.

"Neither men nor animals could long endure work so distressing. Fortunately, the drills knew no weariness nor pain, and churned their way without ceasing to the mines. At length the tunnel drew so near the lode that the men in the Savage Mine could hear the explosion of the blasts, and, soon after, the tapping of the drills on the rock partition. These sounds grew more and more distinct, until, on the 8th of July 1878, a few feet of rock alone separated the two working parties. A blast from the Savage Mine tore an opening through the wall in the evening of that day, and the goal for which Sutro had striven for so many years was in sight. He was waiting at the breach impatient of delay, and crawled, half-naked, through the jagged opening while the hot foul air of the heading was still gushing into the mine. If he seemed overcome by excitement, as reported, it was in no way surprising, for he had triumphed over a host of obstacles, and his indomitable spirit had fairly won success."

The Comstock, wonderful as it was in itself, derived additional romance from a herculean work like this, executed merely as a preliminary to the deep working of the lode. At the time the Sutro tunnel not only took first place among all feats connected with mining, but also rivalled the Mount Cenis and St. Gothard enterprises in the difficulties attending its

construction. We must, therefore, feel sympathy with its promoter, who found that his scheme had been so hampered at the outset by opposition, that, when completed, the need for it had almost passed. The quantity of ore found in the lode below the level (1875 feet) at which the tunnel entered was insignificant in comparison with the huge deposits found between it and the surface, mostly extracted while the tunnel-drivers were straining every muscle to reach the lode. Had Mr. Sutro only been allowed his way in 1866, both he and the owners of the Big Bonanza would have profited enormously.

Now for the Big Bonanza itself, which furnishes the most thrilling episode in the history of one of the world's most interesting mines.

Virginia City and its neighbourhood contained many pessimists in the early 'seventies. Prices were down, expenses were increasing, and many financiers had come to the conclusion that the Comstock as a whole showed distinct signs of being "played out." Mine proprietors had forgotten all about plate-glass windows, champagne, and beautiful fountains, while they endeavoured to keep the balance of the accounts on the right side of the ledger.

While things were in this state Mr. John W. Mackay began to play a prominent part in Comstock history. A man of cool common-sense, extraordinary insight, and bold action, he had risen from day-labourer first to be superintendent of the Cale-

donia Tunnel and Mining Company; then a large shareholder in the Hale and Norcross Mine, as a partner of Mr. James G. Fair. These two Irishmen made a fine working combination. They bought up one property after another, including those between the Ophir and Gould & Curry Mines, which had hitherto been unsystematically and unsuccessfully exploited. The original owners, after joining forces and sinking shafts in search of a rich deposit, concluded that the failure to strike ore indicated a break in the lode, and, losing heart, were ready to sell. Mackay and Fair, acting in partnership with James C. Flood and William O'Brien—Francisco men—purchased the Virginia Consolidated, as it was now called, for about £10,000, determined to venture their fortunes on the chance of finding a "bonanza" at a greater depth than the previous occupiers had attained.

The quartette forthwith sank a deep shaft, and cut a drift to meet it from the Best & Belcher Mine at the 1200-foot level. At first the miners found only barren rock; but just as the "Virginia Con." boundary had been passed a thin seam of ore made its appearance. Mr. Fair followed this pertinaciously as the possible clue to treasure beyond. Sometimes it almost vanished, but never quite; so that the venturers were induced to continue what outsiders regarded as a mere wild-goose chase. Two hundred thousand dollars were spent without result, and the "Virginia Con." tottered on the verge of bankruptcy.

Illness compelled Mr. Fair to be absent for a month, during which time his three partners thought to improve matters by deflecting the line of search from a northerly to an easterly direction. On his return, however, he persisted in following the old course, and in October 1873 the miners cut into a rich ore-body, which was the Big Bonanza. "Of its magnitude and richness," writes Mr. Lord, "all then were ignorant. No discovery which matches it has been made on this earth from the time when the first miner struck a ledge with his rude pick until the present. The plain facts are as marvellous as a Persian tale, for the young Aladdin did not see in the glittering cave of the genii such fabulous riches as were lying in that dark womb of the rock. . . . The wonder grew as its depths were searched out foot by foot. The bonanza was cut at a point 1167 feet below the surface, and as the shaft went down it was pierced again at the 1200-foot level; still the same body of ore was found, but deeper and wider than above. One hundred feet deeper, and the prying pick and drill told the same story; yet another hundred feet, and the mass appeared to be still swelling. When, finally, the 1500-foot level was reached, and ore richer than any before met with was disclosed, the fancy of the coolest brains ran wild. How far this great bonanza would extend none could predict, but its expansion seemed to keep pace with the most sanguine imaginings. To explore it thoroughly was to cut it out bodily; but

the systematic search through it was a continual revelation."

The average yield of this marvellous silver-saturated rock was £600,000 per month for three years! With monthly dividends of about one-third of that amount the four partners quickly became millionaires, rich beyond their wildest dreams. In 1876 Mr. Mackay took out £1,200,000 worth of bullion to make an exhibit at the Philadelphia Centennial Exposition. You can still see in Virginia City a building where £25,000 worth of bullion was melted down daily for over one thousand days, and from which a million sterling started one night on its journey to San Francisco. To sum up, the "Consolidated Virginia" had by 1899 yielded ore worth 26½ million pounds; over half of which passed as profit into the pockets of the proprietors! Such a record can scarcely be matched in the whole history of mining.

Of course, this stroke of fortune affected the whole Comstock Lode. "Why," argued speculators, "should there not be equally rich deposits still lurking undiscovered in other properties?" and they indulged their fancy as deeply as the gamblers of the South Sea Bubble. Servant girls and office boys jostled merchants and professional men in San Francisco in the race for scrip. Shares worth but 50 cents rose to a value of 275 dollars. Then rumours got afloat that the Big Bonanza was not, after all, so extensive as had at first been pictured; and down

came the prices with a run to a third of their top figures, leaving much ruin and wreckage behind them. Fortunately for those who had stuck to their Virginia Consolidated shares, the mine product knew no such fluctuations, increasing steadily until the bonanza became ultimately exhausted.

From the sordid dealings of the money market let us turn to the manly toil of the mines, and borrow yet another picture from Mr. Lord's gallery. "The scene within this treasure chamber was a stirring sight. Cribs of timber were piled in successive stages from basement to dome four hundred feet above, and everywhere men were at work in changing shifts, descending and ascending in the crowded cages, clambering up to their assigned stopes with swinging lanterns or flickering candles, picking and drilling the crumbling ore, or pushing lines of loaded cars to the stations at the shaft. Flashes of exploding gunpowder were blazing from the rent faces of the stopes; blasts of gas and smoke filled the connecting drifts; muffled roars echoed along the dark galleries, and at all hours a hail of rock fragments might be heard rattling on the floor of a level, and massive lumps of ore falling heavily on the slanting pile at the foot of the breast. Half-naked men could be seen rushing back through the hanging smoke to the stopes to examine the result of the blast and to shovel the fallen mass into cars and wheelbarrows. While some were shovelling ore and pushing cars, others, standing on the

slippery piles, were guiding the power drills which churned holes in the ore with incessant thumps, or cleaving the softer sulphurets with steel picks swung lightly by muscular arms . . . . Roman gladiators were scarcely better fitted for their contests in the arena than those Comstock miners for their labours in the heart of the bonanza. All were picked men, strong, young, and vigorous, fed on the choicest food which the Pacific Coast affords, and paid the highest wages earned by any miners in the world. . . . In the hot levels all clothes were laid aside except a simple waist-cloth, and shoes which protected the feet from the scorching rocks. Balanced alertly on wet crumbling heaps of ore, with muscles swelling like flesh waves at every swing of the well-balanced picks, they became models for a sculptor. Their hot blood glowed beneath a skin whitened by a life in dark rock-chambers often dripping with water and reeking with vapour. The variety of their motions had made them a troop of athletes. . . . As one looked upon this swarm of human ants, stoping out and sending up ore from a bonanza whose riches were incalculable, while the vault of the great mine echoed with busy sounds and sparkled with moving lights, it is scarcely surprising that the eyes were dazzled by the vision of the treasure-chamber and the brain heated by enkindled fancies."

The high temperature of the lode walls seriously increased the miner's toil. At a depth of 1700 feet the thermometer showed 104° Fahr.; and when

shafts sank hundreds of feet nearer the earth's centre the heat became so terrific that some men fell dead over their picks; while others were actually *boiled to death* by water into which they accidentally slipped. So exhausting was the effort of hewing the ore in air thus heated, and fouled by the exhalations from the lungs and body, that after a few strokes of his pick the miner had to stand aside to recover himself, while a fellow worker took his place.

Yet human perseverance conquered. The bones of the Big Bonanza were picked clean; Messrs. Mackay, Fair, Flood, and O'Brien pocketed their millions; and the mines, now sadly impoverished and water-logged, passed into other hands.

The "chancy" nature of mining is particularly well illustrated by the contrast between the good fortune of the four partners and the fate of the first discoverers of the Comstock Lode—M'Laughlin, O'Riley, and Comstock. The first, after a life of continual misfortune and hard work, died in hospital, too poor to leave money enough to cover the costs of his pauper burial. O'Riley, his brain turned by unrealised expectations, wore out his health and strength in a tunnel which he drove single-handed into a barren hillside of the Sierra. Angelic voices urged him on to imaginary treasures still far in advance of his pick; his tunnel fell in and maimed him; and at last he was carried off to an asylum, where he died.

The third member of the luckless trio, Henry

Comstock, also became the victim of delusion. Beggared in fact, he still remained in fancy the owner of the entire lode and its cities. A self-inflicted revolver wound terminated his inglorious history; and he now lies in a nameless grave in the wastes of Montana.

The sad note struck by these melancholy incidents attaches also to the later fortunes of the Comstock itself. During 1899 scarcely a dozen men were at work in the vast chasms hewn out by their predecessors. Deep down beneath the water which finds an outlet through the Sutro tunnel are the bottoms of the tremendous shafts, and the deposits deemed too poor to be worth extraction. Virginia City, which Mark Twain has peopled for us with characters of varied pattern, is shorn of her glory. The old mills, once humming with life, are silent; machinery rusts in the rotting shaft-houses; and though the sun still strikes down as formerly on the hillside, it serves but to show how deeply the word "Ichabod" has been traced across the great treasure-vaults of the Comstock.

CHAPTER X

THE MINES OF LEADVILLE

Fifty years ago—Significant names—Early history—First era of mining—Valuable rubbish—Second era—Great profits—A railway episode—Third and fourth eras.

TUCKED away in Colorado between the Rocky Mountains on the west and the Park Range on the east is an elevated plain which slopes gently westwards. Fifty years ago solitude reigned here, among some of the grandest scenery which the United States can offer to the eyes of the tourist. To-day the district is a busy hive; and the rounded hills crossing the plain from north to south have been honeycombed by shafts and tunnels driven in pursuit of gold, silver, lead, and other metals.

Leadville, the commercial centre of the mines, lies towards the western end of the plain. On the east are dotted about dozens of properties, named in a manner suggesting either their nature or some incident connected with their history. "Nil Desperandum" conjures up a picture of the miner working against heartbreaking disappointment. In "Only Chance" we see the last card being played by the impoverished prospector. "Resurrection" betokens the mending of broken fortunes. "Ready Cash" speaks of early success. In "Evening Star,"

"Silver Cord," "Forest Queen," "Star of the West," imagination has had play; and "Little Vinnie," "Adelaide," "Dolly B.," "Fanny Rawlins," "Nettie Morgan," "Lillian," and "Minnie," perhaps indicate that the owner has in mind "the girl he left behind him" when he sallied forth in search of fortune among the hills.

The mining history of the Leadville district dates from 1860, when some gold-hunters crossed the Park Range and entered a—then—heavily-timbered ravine, through which flowed a feeder of the eastern fork of the Arkansas river. The locality looked promising. Pans and rockers were soon busy, "colour" appeared, and the stream, once limpid, became turbid and yellow after its passage through the rough apparatus of the miners.

Some claims panned out a thousand dollars a day for weeks together, in spite of the shortage of water. Thousands of men flocked in to share the spoil. A large camp rose on either side the stream, with the usual array of stores and drinking saloons wherein gold dust was bartered for flour or whisky. The altitude of Leadville,—over 10,000 feet above sea-level—means a long and hard winter, during which the miners, swallow-wise, migrated to Denver and other milder localities, waiting for the next spring to return to their claims.

The first era of Leadville history covers the years 1860 to 1869. The camp saw its best days in 1861, and gradually declined till 1868; by which time the

"placers" had yielded some four million dollars' worth of gold. For the next decade little was done in the district beyond some quartz-mining; though prospectors were busy seeking fresh openings for labour and capital.

We have seen how, in Nevada, gold-mining had led to the discovery of silver. The same thing happened in Colorado; and, as in the case of the Comstock deposits, the early miners at Leadville threw aside as worthless material which, to the expert eye, betrayed a fortune ready to be gathered. The workers in California Gulch grumbled at the weight of boulders obstructing their operations. But when W. H. Stevens, a wealthy miner, and A. B. Wood, came on the scene to organise a twelve-mile flume for the gulch, they took the trouble to investigate the nature of this heavy "rubbish," and found that it was carbonate of lead containing a high percentage of silver. They kept the discovery to themselves until they had secured several claims along what they considered to be the outcrop.

From this year, 1878, dates the second era of Leadville mining, the "carbonate period," as it has been called. In a few months a strong stream of immigration had commenced, people flocking in from all parts of the States; before a year had passed the population had increased twenty-fold. Leadville became a magnet, towards which long trains of waggons moved slowly along overcrowded roads. A Bank and a Post Office were established, and

round these a town sprang up; one of the liveliest towns of the day. At nightfall, pleasure-seekers crowded the streets, spent their money recklessly, and enriched those who catered for their wants. Building sites, which a short time before could have been bought for a few dollars, fetched thousands. Fortunes were made by lucky speculators without the trouble of touching a pick.

The carbonate zone runs north and south, with a dip eastwards at an angle of about twenty degrees below the vertical; the carbonate lying between a covering of porphyry and a sub-stratum, or foot-wall, of limestone. The veins struck varied in thickness from a mere streak to thirty feet, and were so soft as to be extracted by the pick without blasting. Some of the ore yielded 400 dollars' worth of silver per ton, and 75 per cent. of lead. From the Little Pittsburgh, New Discovery, and Winnemuck mines on Fryer's Hill, to the north-east of the town, ore valued at over 3,000,000 dollars was extracted in six months. In the second of these mines a great "bonanza" appeared at a very moderate depth—between 100 and 200 feet below the surface. So large was the excavation that the owners had to resort to the system of timbering employed in the Big Bonanza of the Comstock.

The Leadville mines of the second era were very shallow as compared with those on the Comstock Lode: and their working was therefore very profitable until the price of silver fell in consequence of the

quantities of the metal extracted in Colorado and Nevada. Owned by "closed" companies of a few members each, who kept the shares out of the market, they never became the subject of such wild speculation as we have already had to notice in the case of the Gould & Curry and other big Nevada ventures; nor has their working been distinguished by lavish and reckless expenditure. On the contrary, the Leadville mines afford a good example of efficient and economical management.

The "carbonate period" is connected with a stirring episode in American railway history. The 'seventies were notable for the extension of the transcontinental lines. The Atchison, Topeka, and Santa Fé had reached the edge of New Mexico in 1878, bound for the Pacific Coast. Its promoters had an eye very widely open for intermediate branches, and the discovery of silver in the Leadville region that year immediately suggested the reflection that a side track penetrating the Park Range into the plateau might bring some very pretty returns, considering the charges then prevailing on the roads. There was only one practical approach to Leadville, through the Grand Cañon eaten out by the Arkansas River; and this the Rio Grande and Denver magnates already regarded as their own, since Colorado was their particular sphere of action. Getting wind of the Santa Fé people's intention to seize the pass and gain the "right of way" by commencing work, they despatched a trainload of Denver employés

to anticipate such a move. Mr. W. R. Morley, a Santa Fé engineer, proved too quick for them, driving furiously across country to Cañon City while the train slowly wound its way over the metals. He collected a handful of backers, and by dawn had moved the first shovelful of earth; much to the disgust of the rival faction, who arrived in time to look down the muzzles of an assortment of firearms.

It looked as if there would be a fight for the Pass. But the West had advanced sufficiently in civilisation to have recourse to the more peaceful methods of the courts. As the result of a long and notable lawsuit, the Denver party compromised and leased the whole of their narrow-gauge system to the Santa Fé. The latter at once began to build a second line through the Pass on their own account; and this being construed as an act of perfidy, the conflict broke out again. Different judges gave different decisions; the employés took a spirited and practical part in the fight; law and order were for the time set at naught. When it came to actual force of arms the Santa Fé got the worst of the bargain, and were finally expelled from their occupation. Such vigorous measures showed that the Leadville traffic was a prize worth fighting for.

With the decline in the value of silver, Leadville declined also. But it did not fall, since there was still gold in the district, as Mr. John F. Campion discovered in 1891, when he sank a shaft on Breece Hill, to the east of the city. The Ibex Mining

Company was formed. In eight years it extracted gold worth 13,000,000 dollars. Other corporations did almost equally well. The third era, built, like the first, on gold, produced many large fortunes.

At present the fourth era of Leadville is running its course. Gold, silver, lead, copper, zinc, and iron are all treated, as the baser metals have risen in value.

CHAPTER XI

THE MINES OF SILVERLAND

Mexico as a silver producer—What Humboldt found in 1802—The total production of silver—Huge lumps of solid metal—Sensational fortunes—A lucky priest—A millionaire fiddler—Two fortunate peasants—The "Good Success" Mine—The mines of Zacatecas—The mines of Guanajuato—The Valenciana Mine—The Marques de Rayas—Mexican mining law about depth of claims—Zacatecas wealth.

Of all the silver mined yearly throughout the world Mexico yields one-third, which is assessed at a value of about £15,000,000. Thanks to the enormous deposits of Nevada, Montana, Colorado, Utah, and Idaho, the United States come in a very good second with fourteen million sterling; but other individual countries are "nowhere."

It was gold that attracted Cortez to the land of the Aztecs in the sixteenth century. The natives, ignorant of silver mining, had amassed, as we have already noticed, large quantities of the more precious metal; though their total accumulations were a mere trifle in comparison with the silver wealth which they left untouched. Silver! Silver! Silver! is the cry which now draws engineers, capitalists, and adventurers of all classes to the Republic so ably ruled by Porfirio Diaz, a man whose career is as full of romance as that of the country which he has

rescued from chaos and given a leading place among the Transatlantic nations.

Silver is found in most parts of Mexico, either as pure metal, or in chemical combination with various other minerals. But the provinces most distinguished by their silver mines are (refer to your map) Sonora, Chihuahua, Durango, Zacatecas, S. Luis Potosi, Guanajuato, and Hidalgo—to name them in their due order from north to south. When Humboldt visited Mexico in the beginning of the nineteenth century he calculated that the great silver lodes were honeycombed by 3000 to 5000 mines, each of which had several shafts and many galleries; and he reckoned the silver extracted since the Spaniards first began work to be worth £130,000,000. These figures are now quite eclipsed, for recent calculations assess the total value till the end of the last century to be £800,000,000 sterling!

What these colossal figures mean may be concretely represented by assuming that the silver has had an averaged price of 3s. 4d. per ounce. If you care to work out an arithmetic sum, taking as your basis the fact that one cubic foot of silver weighs 10,700 odd ounces, you will arrive at about 450,000 cubic feet, which would suffice for a pillar of metal ten feet square and higher than the loftiest mountain in the British Isles!

That such huge quantities should have been mined is due to the "kindly" nature of the ore, which permits it to be reduced by comparatively primitive

methods. Many of the lodes or veins are "rotten," or crumbling; and in places masses of solid silver have been found which completely eclipse the records of other countries. The mine of Arazuma, in Sonora, takes first place as the producer of monster silver nuggets. So sensational are the figures that we should hardly dare to quote them, were they not backed by unimpeachable testimony. At Arazuma, then, in the middle of the eighteenth century, the owner paid duty on several pieces which together weighed 4033 lbs., the largest lump scaling 2700 lbs.—or about a ton and a-fifth! Even the largest gold nuggets of Australia hardly equal this in value.

You will easily understand that in a country so impregnated with precious metal many enormous fortunes must have been made during the three and a-half centuries during which the miner has been at work there. The stories of individual success and attainment of dazzling wealth would suffice to fill a large volume, and we must therefore but briefly notice the luck of a few persons and the productiveness of a limited number of mines.

In the midst of bleak and precipitous mountains in the State of San Luis Potosi (not to be confused with the Potosi of Bolivia) is the Flores Mine. It was discovered by a priest, who, tired of his life as a starved cleric, bought for a mere trifle a claim which was being abandoned as worthless. After following the vein a little distance he struck a

cavern in the rock full of "rotten" ore, out of which he mined over £600,000 worth of silver!

Again, in this same region, in 1778, a negro fiddler, overtaken by night while returning home from a dance, built a fire, among the ashes of which he discovered, next morning, a button of virgin silver. The outcrop, thus fortunately brought to light, made him a millionaire.

The Moreton Mine, Sonora, was struck in 1826 by two Indian peasants, so poor that, on the night before their great discovery, the keeper of the store had refused to credit one of them for a little corn for his *tortillas* (cakes). They extracted from their claim 270,000 dollars; yet, in December 1826, they were still living in a wretched hovel, close to the source of their wealth, bare-legged and bare-headed, with upwards of 200,000 dollars in silver locked up in their hut. Never was the utter worthlessness of the metal, as such, so clearly demonstrated as in the case of these peasants, whose only pleasure was to gloat over their hoards, and occasionally throw a handful to be scrambled for by their less fortunate neighbours.[1]

The "Good Success" Mine was found by an Indian who swam a river after a heavy flood. On arriving at the other side he found the outcrop of an immense vein which had been laid bare by the force of the current. All the inhabitants of a neighbouring town went out to see this wonder. Though

[1] *Vide* Ward's "History of Mexico," vol. ii. p. 578.

he was prevented by water inroads from going deeper than about three yards, he took out a large fortune. Of a neighbouring mine (the *Pastiano*) Ward writes: The ores were so rich that the lode was worked by bars, with a point at one end and a chisel at the other, for *cutting out* the silver. The owner of the Pastiano used to bring the ores from the mine with flags flying, and the mules adorned with cloths of all colours. The same man received a reproof from the Bishop of Durango when he visited Batopilos for placing bars of silver from the door of his house to the great hall for the Bishop to walk upon. The *Santa Eulalia* Mine yielded so enormously that two and a-half per cent. of the silver extracted in a few years sufficed to build the magnificent Cathedral of Chihuahua.

So much for Sonora. Anything that can be said of this province can be said several times over for Zacatecas, Guanajuato, and Hidalgo. The first two of these have been rivals for first place among the states as silver producers. Both have had their ups and downs; the one being "in bonanza" when the fortunes of the other were low; and then a turn of Fortune's wheel would reverse their positions. Since Cristobal de Oñate located the Tanos de Panuco, in 1548, the mines of Zacatecas have yielded over £200,000,000 sterling. The Guanajuato ore deposits, first tapped in 1554, have given up an equal amount. The Valenciana Mine, when visited by Humboldt, had in four years produced 13,896,416

ounces of silver. It was opened in 1760 on the "Mother Vein" at a point where some work had been done in the sixteenth century, and which had been neglected afterwards for two centuries as unsatisfactory. A rich "bonanza" was struck eight years later at a depth of 240 feet, and £300,000 were extracted annually. A town of seven thousand inhabitants was built near the mine, which gave employment to 3100 people. A large octagonal shaft was sunk to a depth of 2000 feet, and the mine was explored by it in lower parts. But the rich ore extended only to the depth of 1200 feet, below which it was then too poor to be worth extracting. In 1810 the mine filled with water. Fifteen years later the Anglo-Mexican Company (of which more presently) freed the mine at great expense, but did not succeed in making it pay. The United Mexican Company, which afterwards took it in hand, managed, however, to extract an immense quantity of paying ore. A peculiarity of this shaft is a spiral path cut over 500 feet down through the rock at such an angle that mules can walk up and down it.

The other great mine of Guanajuato is the *Marques de Rayas*, or *Los Rayas*. In connection with it we may notice a feature of Mexican mining laws, which give to the discoverer of a lode a right to dig only 500 feet down under his claim. "The consequence of this limitation is, that when a very rich claim is made, there immediately springs up a contest to get below it, and to cut off the lucky discoverer from

the lower part of his expected fortune, and he has no means of avoiding such a result but by driving his shaft downward until he reaches a point below his first 200 *varas* (500 feet), which entitles him to claim another section downward."[1] The Marquis de los Rayas, being a determined digger, got down so deep that he claimed a second stratum of 500 feet before rivals had penetrated obliquely, and so netted a fortune of over £2,000,000; thanks to the ore being so rich in gold that it often sold for its weight in silver.

With silver so plentiful, many extravagances were committed. "One Zacatecas miner paved the street with ingots from the Casade Gobierno to the Parroquia (between fifty and sixty yards) for a christening procession. In 1800 the Viceroy Ananga passed a law forbidding godfathers to fling handfuls of coin into the street on such occasions. It was easy come, easy go, as always where there are bonanzas; with the difference that even a parvenu Spaniard spends his money, not like a parvenu, but like a prince."[2]

The province of Hidalgo contains two very famous mines, the San Gertrudis and the Real del Monte. The story of the last is so interesting, and in many ways so typical of Mexican mining history, that we will devote a special chapter to its fortunes.

[1] Wilson's "Mexico," p. 377.
[2] "The Awakening of a Nation," C. F. Lummis, p. 30.

CHAPTER XII

THE REAL DEL MONTE

The Real del Monte—Early history—Mexican mining laws—Bustamente and Terreros—The great adit—Huge profits—Kingly favour and great promises—Water again causes trouble—Decline of the Real—English enterprise—Mexican mining mania—Great energy of new owners — Their mistake — Checked by water — The crash — Third chapter of the mine's history—Below ground—Thefts of miners—The refineries—The patio process—Silver and Silverland.

PACHUCA, in Hidalgo, is the oldest mining district of Mexico. The mines in its immediate neighbourhood were the first in which the Spanish conquerors forced slaves to work for them. Ten miles from Pachuca, among glorious scenery, is the village of Real del Monte, on ground honeycombed by shafts and adits. As long ago as 1826, when English enterprise had begun extending the workings of the Real Mine, Mr. Ward wrote: "The possessions of the Real del Monte Company on the two great veins of Santa Brigida and La Biscaina cover a space of 11,800 yards, and are intersected at intervals by thirty-three shafts, varying in depth from 200 to 270 yards, but all sunk with a magnificence unparalleled in Europe. The whole of these shafts, together with the great *adit* (or tunnel for draining the mine), which follows the direction of the two great veins, branching off from the Santa Brigida

vein at the point where it intersects that of the Biscaina, and from which the wealth of the Regla family was principally derived, was delivered over to the Company in July 1824 in a state of absolute ruin. Many of the shafts had fallen in (though cut, at intervals, in the solid porphyritic rock); in others, the timbers had given way; and in all, as the adit was completely choked up, the water had risen to an enormous height."

But this is anticipating. Very little is known of this mine prior to 1749, beyond the fact that its surface workings had yielded considerable quantities of silver. In olden times water had been lifted from the mine in bulls' hides carried up on a rope, a method so primitive and inefficient that when a comparatively small depth had been reached, the water got the upper hand and caused the abandonment of the property at the beginning of the eighteenth century. As has been well said, no wreck is more complete than that which water causes when it once gets possession of a mine, and "mingles into one mass floating timbers, loosened earth, rubbish, and soft and fallen rock."

The mining laws of Mexico, like those of some other countries, stipulate that a title of ownership shall be maintained by work and work alone. When once a mine is abandoned, anybody can "denounce," or claim, it, on condition that he works it.

Now, an intelligent miner, named Bustamente, saw his chance. The water was there; but metal

was there as well. If the former could be drained off, the latter could be easily extracted. He accordingly joined forces with one Peter Terreros, an enterprising merchant (though some accounts make him an ignorant muleteer), to drive an adit into the side of the hill which should enter the Biscaina vein at a depth of 200 yards below the surface. To effect this the tunnel would have to be 3000 yards long. The undertaking, though enormously expensive and very arduous, was persevered in by the two partners, who fortunately from time to time encountered veins which paid all costs. Bustamente died before the completion of the work; but in 1762 Terreros had the satisfaction of cutting into the Biscaina and seeing the water rush out into the valley. Adolph Sutro a century later, as we have already noticed, performed a similar but much greater feat at the Comstock Lode.

When he reached the main shaft, he had a ruin to clear out and rebuild, which was a more costly undertaking than the building of a king's palace.

But if the toil had been great, the reward was greater still. In twelve years Terreros took out over £3,000,000. Of this he spent two and a-half million dollars on the mines and refineries; laid out six million dollars on plantations; and loaned the King of Spain a million (which were, of course, not repaid). For this handsome pecuniary help, and the present of two fully equipped ships of the line, the once humble Peter Terreros was ennobled as the Count of Regla. "Among the common people

he is the subject of more fables than was Crœsus of old. When his children were baptized, so the story goes, the procession walked on bars of silver![1] By way of expressing his gratitude for the title conferred on him, he sent an invitation to the king to visit him at his mine, assuring His Majesty that if he would confer on him such an exalted favour, His Majesty's feet should not tread upon the ground while he was in the New World. Wherever he should alight from his carriage it should be upon a pavement of silver, and the places where he lodged should be lined with the same precious metal.[2] Anecdotes of this kind are innumerable, which, of course, amount to no more than showing that in his own time his wealth was proverbial, and demonstrate that in popular estimation he stood at the head of that large class of miners whom the wise king ennobled as a reward for successful mining adventures, and that he was accounted the richest miner in the kingdom. The state and magnificence which he sometimes displayed surpassed that of the vice-king. This in no way embarrassed an estate, the largest ever accumulated by one individual in a single enterprise."[3]

[1] The rich Mexicans seem to have had little originality in their methods of making a display. Street paving was, however, economical, as the silver could be collected again.—AUTHOR.

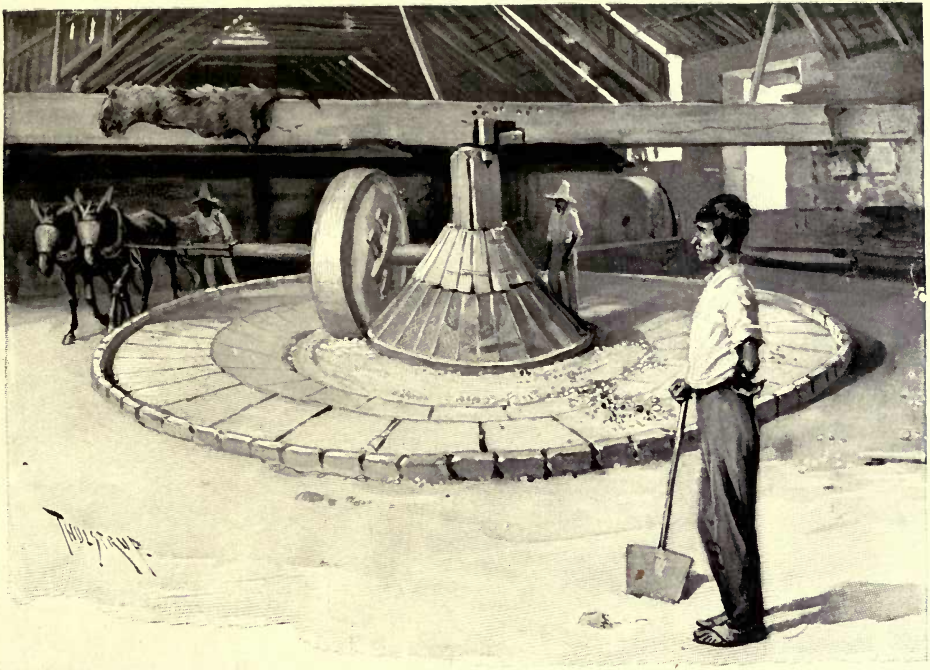
[2] Mr. Charles F. Lummis, in his "Awakening of a Nation," says that Terreros promised to pave the road from Vera Cruz to Mexico (550 kilometres) with silver ingots. No doubt he had very decided ideas about the probability of a kingly visit before he made this promise.

[3] Wilson's "Mexico," p. 365.

Terreros' son found the work of extracting ore more difficult than had his father, for in his time the shafts had sunk so far below the adit level that the original trouble with water was repeated. He installed horse-machinery, called *malacates,* which raised the water in skins to the adit and discharged it. As the mine grew deeper, more and more malacates became necessary, until twenty-eight were at work, turned by twelve hundred horses, superintended by four hundred men. A quarter of a million dollars were spent annually on the draining; and eventually the deeper galleries had to be abandoned—though they yielded 400,000 dollars per annum—and operations were confined to the upper levels.

On the death of the second Count the mine declined, and its activity ebbed very low during the War of Independence in 1821, which severed Mexico from the Spanish Crown. The Terreros family kept their title good by employing a few workmen about the shafts.

As soon as the independence of Mexico had been recognised by Great Britain, English capital began to flow into the new Republic. During the years 1824–1827 a regular mania for speculation in Mexican mines seized the British public. To quote Mr. Wilson's vivid words once again, "That second South Sea delusion, the Anglo-Spanish American mining fever, broke out in England. It surpassed a thousand-fold the wildest of all



The Molino, or crusher, used in Mexican silver reduction works for breaking ore into small pieces. A large stone disc, drawn round by mules, acts in the same way as the rollers of an ordinary mortar-mill.

the New York and Californian mining and quartz organisations of the last five years.[1] Prudent financiers in London ran stark mad in calculating the dividends they must unavoidably realise upon investments in a business to be carried on in a distant country, and managed and controlled by a debating society or board of directors in London. Money was advanced with almost incredible recklessness, and agents were posted off with all secrecy to be first to secure from the owner of some abandoned mine the right to work it before the agent of some other company should arrive on the ground. No mine was to be looked at that was not named in the volumes of Humboldt, and any mine therein named was valued above all price. In the end, some 50,000,000 dollars of English capital ran out and was used up in Mexico. It was one of those periodical manias that regularly seize a commercial people once in ten years, and for which there is no accounting, and no remedy but to let it have its way and work out its own cure in the ruin of thousands."[2]

While finance was thus distracted a company, known as the Real del Monte Company, was formed to drain the Real mines and render them workable. Their condition at this period has already been described. Besides, all the machinery in the

[1] The Comstock mania was still in the future, or these words might have been qualified.—AUTHOR.

[2] Wilson's "Mexico," pp. 354-355.

large reduction works, formerly used to extract the silver from the ore, had been destroyed or carried off, and as the war had almost obliterated the villages round, workers were hard to find.

Englishmen are not easily discouraged. The necessary capital having been subscribed, 1500 tons of machinery, including five large steam-engines, a stamp, saw-mill engines, and pumps, were sent out in May 1825 to Vera Cruz. Even when the three ships carrying the material had discharged their cargoes, after great difficulty on account of the exposed and dangerous anchorage, trouble had only just begun. Three hundred miles of rutty and hilly roads had to be traversed by the transports, drawn by seven hundred mules under the direction of one hundred men. This process occupied five months and cost a million dollars, a sum equal to the original value of the machinery! Meanwhile a detachment at the mines had cleared the adit; repaired many of the shafts; erected buildings round the property; and built a finely engineered road from the mines to the reduction works through the rocky ravine which intervenes. The pumps were erected, and hopes rose high.

Unfortunately, the promoters made an initial mistake which ruined their venture. Instead of trying to drain the mines by a tunnel driven below that of Terreros, at the level of the bottom of the existing workings, they decided to *pump* the water into the old adit. At first all seemed to go well,

since two small steam-engines, working pumps that lifted 600 gallons per minute, easily accomplished what the twenty-eight malacates had failed to do. But the galleries drained did not prove very remunerative, and the engineers therefore decided to sink a large shaft farther along the vein. The manner of sinking of this was, at the time, a novel engineering feat, for instead of proceeding from the top only, the engineers drove five galleries at different levels from the old workings to spots under that which had been fixed for the mouth of the shaft, and worked simultaneously both upwards and downwards from these five levels. The shaft was finished in 1834, and it must be placed to the credit of those responsible that when the sections met they made a hole as straight and perfect as if a shaft had been sunk from the surface direct.

The new treasure-house reached through this shaft was worked profitably for a time, excavations reaching downwards to a point 720 feet below the adit. Then the difficulty of drainage made itself felt. Three large pumps, discharging between them 2700 gallons a minute, could scarcely keep the water in check. The cost of pumping ate up all the profits. Shares which had risen from £100 to £4800 in value, fell, fell, fell, till in 1845 they could be bought for fifty shillings apiece! The company, worn out by a losing fight with the water, gave up the struggle; and a property on which 20,000,000 dollars had been expended passed into the hands

of other people for £25,000! This was indeed a sad ending to the second chapter of the Real's history!

A Mexican syndicate bought the mines and all appertaining thereto for "a mere song"—as indeed the amount named above must appear in comparison with the intrinsic value of the silver deposits still left untouched. Mr. Buchan, the engineer of the new company, at once commenced to drive a drainage tunnel 400 feet below that of the first Count. It had to pierce nearly a mile of very hard rock before it reached the great Dolores shaft. Then the water got away, and the third chapter, which may be said to last to the present day, commenced. In 1856 five thousand men and countless animals were at work.

For a pen picture of the mine at this time we must once again appeal to Mr. Robert A. Wilson's interesting book. Clad in a skull-cap, miner's pants and coat and calf-skin boots — an oddly assorted garb—he descended one of the main shafts. "While standing at the top of the shaft," he writes, "I was astonished at the size and perfect finish of the steam pump that had been imported from England by the late English mining company. With the assistance of balancing weights, the immense arms of the engine lifted, with mathematical precision, two square timbers, the one spliced out to the length of a thousand, the other twelve hundred feet, which fell back again by their own weight: these were the pumping-rods which lifted the water four hundred

feet to the mouth of a tunnel or adit, which carried it a mile and a quarter through the mountain, and discharged it in the creek. . . . A trap-door being lifted, we began to descend by small ladders that reached from floor to floor in the shaft, or, rather, in the half of the shaft. The whole shaft was perhaps fifteen or twenty feet square, with sides formed of solid masonry, where the rock happened to be soft, while in other parts it consisted of natural porphyry rock cut smooth. Half of this shaft was divided off by a partition, which extended the whole distance from the top to the bottom of the mine. Through this the materials used in the work were let down, and the ore drawn up in large sacks, consisting each of the skin of an ox. The other half of the shaft contained the two pumping timbers, and numerous floorings at short distances; from one to the other of these ran ladders, by which men were continually ascending and descending, at the risk of falling only a few feet at the utmost. The descent from platform to platform was an easy one, while the little walk on the platform relieved the muscles exhausted by climbing down. With no great fatigue I got down a thousand feet, where our further progress was stopped by the water that filled the lower galleries.

"Galleries are passages running horizontally from the shaft, either cut through the solid porphyry to intersect some vein, or else the space which a vein once occupied is fitted up for a gallery by receiving

a wooden floor and a brick arch overhead. They are the passages that lead to others, and to transverse galleries and veins, which, in so old a mine as this, are very numerous. When a vein sufficiently rich to warrant working is struck, it is followed through all its meanderings as long as it pays for digging. The opening made in following it is, of course, as irregular in form and shape as the vein itself. The loose earth and rubbish taken out in following it is thrown into some abandoned opening or gallery, so that nothing is lifted to the surface but the ore. Sometimes several gangs of hands will be working upon the same vein, a board and timber floor only separating one set from another. When I have added to this description that this business of digging out veins has continued here for near three hundred years, it can well be conceived that this mountain ridge has become a sort of honeycomb.

"When our party had reached the limit of descent, we turned aside into a gallery, and made our way among gangs of workmen, silently pursuing their daily labour in galleries and chambers reeking with moisture, while the water trickled down on every side on its way to the common receptacle at the bottom. Here we saw English carpenters dressing timbers for flooring by the light of tallow candles that burned in soft mud candlesticks adhering to the rocky walls of the chamber. Men were industriously digging upon the vein, others disposing of the rubbish, while convicts were

trudging along under heavy burdens of ore, which they supported on their backs by a broad strap across their foreheads. As we passed among these well-behaved gangs of men, I was a little startled by the foreman remarking that one of those carriers had been convicted of killing ten men and was under sentence of labour for life. Far from there being anything forbidding in the appearance of these murderers, now that they were beyond the reach of intoxicating drink, they bore the ordinary subdued expression of the Meztizo. According to custom, they lashed me to a stanchion as an intruder; but, upon the foreman informing them that I would pay the usual forfeit of cigaritos on arriving at the station-house, they good-naturedly relieved me. Then we journeyed on and on, until my powers of endurance could sustain no more. We sat down to rest, and to gather strength for a still longer journey. At length we set out again, sometimes climbing up, sometimes climbing down: now stopping to examine different specimens of ore that reflected back the glare of our lights with dazzling brilliancy, and to look at the endless varieties in the appearance of the rock that filled the spaces in the porphyry matrix. Then we walked a long way on the top of the aqueduct of the adit, until we at last reached a vacant shaft, through which we were drawn up and landed in the prison-house, from whence we walked to the station-house, where we were dressed in our own clothes again."

Like the Kaffirs of the Kimberley diamond mines, the Mexican workmen are adepts at stealing. They try every possible device which may enable them to carry off pieces of rich ore. The hollow handles of hammers, the ears, the spaces between the toes, the mouth, and cigarettes, all serve as hiding-places. Accordingly the men are carefully searched three times when leaving work.

The Real del Monte mines have been worked with profit ever since the Mexican company took them over, new deposits being struck from time to time.

Not the least interesting features of a great mine are the reduction works, or *haciendas*, where the silver is extracted from the ore. Twelve miles from the Real is the Regla hacienda, built by the first Count in the bottom of a very picturesque valley. It is a very extraordinary group of buildings, externally much resembling a castle, since the massive walls are loopholed for defence. Inside are magazines, courts, furnaces, mills, smelting and amalgamation works, built over dungeons, vaults, and tunnels.

Let us enter a mill and see how the Mexicans treat the ore. In a large yard boys and women are breaking up the ore with hammers. When broken, it is sorted, the useless rubbish being cast aside, and the rich portions being placed in a *molino*, which is somewhat like the mortar-crusher used on large building operations. Large circular stone rollers are drawn round and round in the trough of the *molino* by mules, until the pieces of

The Mexican Patio *process of silver reduction. The ore, after being broken in the Molino, and reduced to a paste in the Arrastra, is turned on to a floor paved with stones and surrounded by a low wall, where mules trample it for several weeks, mercury and other chemicals being added gradually. When the amalgamation is complete the "torta," or compound, is washed and retorted.*

ore have been broken up very small. The stuff is then transferred to an *arrastra*, a basin 9 to 12 feet in diameter, lined with cement. Heavy stone blocks, moved round by animal or water power, reduce it and the water which has been gradually added, to a kind of thick mud paste. The mass is next poured out on a large floor carefully paved with stones or wood and enclosed by vertical sides. After it has been allowed to dry a few days, salt is added and mules are turned in to tramp it for two or three days. Sulphate of copper, lime, and quicksilver are thrown in also, and the trampling continues for seventy more days. According to some writers the quicksilver and other chemicals rapidly destroy the hoofs and tails of the poor mules; though others say that the evil effects are small. Judging, however, by the damage done to plumbers and other workers in metal by metallic poisoning, we can easily understand that continuous immersion in a chemical mixture such as has been described might soon prove disastrous to animal tissues.

Presently the time comes when the official "tester" must decide whether the mercury of the *torta*, or paste, has been fully amalgamated with the silver. On his judgment depends, perhaps, the fate of several thousands of pounds' worth of metal. He is responsible for the proportion in which chemicals must be added to secure the best results with any one *torta*. The quality of the ore varies,

and its treatment must also vary according to its nature. When he gives the word, the mass is carried to an immense washing machine, driven by water, which separates and expels the dross, leaving the silver-impregnated mercury. The amalgam is then retorted and cast in bars for minting or export.

Foreign capital is, of course, altering mining methods, and the *patio* system just described will doubtless give place in the future to one more scientific. At present, however, it holds its own as being very cheap and yet effective, though tedious.

Silver is doing for Mexico what precious metals have already done for many other countries. Apart from enriching the actual owners and citizens, it has caused the settlement and cultivation of large areas upon which a mining population must depend for its subsistence. The increased need for transport of silver and machinery is responsible for the ever-increasing network of railways, which at the coast terminate in fine harbours—a notable instance of enterprise being the new port at Vera Cruz. Besides her great mineral deposits Mexico has what is even more valuable, a stable Government controlled by a great-minded man, who not only himself has clearly before him the path which he wishes his country to pursue, but also has instilled into his helpers a large portion of his own enthusiasm, so that when he is taken worthy successors will be left to continue his work.

CHAPTER XIII

THE COPPER MINES OF THE RIO TINTO

The natural riches of Spain—Early miners—The Carthaginians—The Romans—Blindness of Spaniards—The irony of history—The Rio Tinto—Modern development—Vallejo—Vaillant—Lieberto Wolters—Early company promotion—Report on the Rio Tinto's resources—Samuel Tiquet—Thomas Sanz—The Spanish Government tries its hand—The Marquis de Remise—The Government decides to sell its rights—French invaders—German invaders—Doetsch, Sundheim, and Blum—A gigantic payment—The Rio Tinto Mine—Separation of copper from its ore—Spain's future—"Wanted."

THE effect of misrule and maladministration on Spain has been to place her among the lesser Powers of Europe. Stripped of her colonies by secession after secession early in the nineteenth century; stripped of her navy, Cuba, and the Philippines by the disastrous war with the United States, Spain, who once yielded to no other nation in pride and might, who shook the nations of the New World with but a handful of her chivalry, and sent against England the mightiest Armada that had yet been seen, now stands apart, poor, proud, and reserved, waiting till Fortune shall give her rank and prestige again.

To imagine that Spain is a country without natural resources would be to commit a grievous mistake. Gold, silver, copper, tin, iron, lead, coal, quicksilver—she has them all generously stored in her rugged

bosom; so that, were her wealth properly exploited, she would probably eclipse the output of any other European country.

The richness of her mineral supplies was discovered many hundreds of years ago by the Phœnicians, who mined for gold along the Guadalquiver before the time of David. Later on, her silver stores came to light, and the Carthaginians raided the country to get labour for the mines. After the fall of Carthage, the Romans took up the work, transporting thousands of captives to toil in the mines which they had formerly owned. They produced large quantities of silver and copper, besides gold, and have left their marks in many a fold of the Sierras. In course of time the riches thus won from Spain made Rome over-wealthy, and she shared the fate of luxurious nations. The Goths, Vandals, and Moors, who overran the Peninsula, did little mining. The lodes opened by their predecessors remained idle for centuries. Even when Spain was at the zenith of her power, with Ferdinand and Isabella on the throne, her people, straining eagerly to the El Dorados of Mexico and Peru, were oblivious or ignorant of the greater wealth lying neglected beneath their very feet. "It is a strange example of the irony of history, that when Columbus sailed on his first voyage to America, he left behind him, within fifty or sixty miles of the fishing port he sailed from, mineral deposits which were destined to produce a more famous mine of its kind than has yet been discovered across the Atlantic.

A general view of the North Lode "Open Cast," at the Rio Tinto Mine. This is one of the largest mining

Copper Mines of the Rio Tinto

The dark waters of the Rio Tinto on which his pioneer ships floated out into the unknown ocean, owe their colour to a mountain of copper which has yielded almost as many solid millions of money as have been got out of the Comstock Lode, or the Calumet and Hecla." [1]

The name of the subject of this chapter having now been mentioned, we may turn at once to the history of one of the world's most remarkable mines; remarkable alike for the vicissitudes through which it has passed, its extent, and the vastness of its wealth.

Let us, then, first be quite clear as to the Rio Tinto's position on the map. So follow down the boundary line between Spain and Portugal till you reach the province of Huelva, and about thirty miles north of the town of that name, you will find "Los Minas de Rio Tinto" on the southern slope of the Sierra Morena. From this district—for district it is rather than a place—comes one-tenth of the copper mined annually in the world.[2]

Who first delved here for the metal is, and must remain, uncertain. Indeed, we do not get on the scent of facts till the middle of the sixteenth century, when a formal report, containing some truth and a good deal of fiction, was made on the mines by Government inspectors. It drew so rosy a picture of the deposits that a Don bought the right of working

[1] "Spain of To-Day," W. R. Lawson.

[2] In 1901, 1,928,776 tons of ore were mined, and about one-third of this exported. Over 20,000 tons of pure copper were smelted at the mines alone.

them, with what success we do not know. A century or more passes, and Don Sebastian Vallejo is found busily engaged in the Sierra precipitating copper from the ore. He, too, disappears into obscurity, while Don Nicholas Vaillant emerges, secures a lease for thirty years, and fails to make anything out of his privileges.

The first really practical man to attack the great riches of the Rio Tinto was a Swede, Lieberto Wolters by name. In the early part of the eighteenth century Sweden lost much of the prestige won by Gustavus Adolphus, Charles X., and Charles XII.; but with the passing away of her military power, her commercial enterprise, stimulated no doubt by the great wars in which she had engaged, did not disappear also. Swedes penetrated into all parts of Europe, and became pre-eminently successful as miners.

Wolters, a native of Stockholm, came to Spain in or about the year 1700. At first he practised the profession of a diver in Vigo Bay, and probably made a good profit out of his work, since in 1725, when the Rio Tinto mine was in need of a lessee, he offered to lease it and form other mines for thirty years, agreeing to pay the Crown a royalty of one-thirtieth of the ore mined.

Not being rich enough to finance the undertaking entirely by himself, Wolters took the step which to-day marks the beginning of so many commercial enterprises. He promoted a company, with a capital

of 100,000 doubloons, or nearly £400,000 sterling.[1] Of the 2000 shares, Wolters kept 700 for himself, as "vendor's shares," and threw the other 1300 open to public subscription. It is interesting to note how closely he followed modern methods. Shareholders were given the opportunity of paying in instalments—five doubloons on application, ten on the last day of May 1726, ten on July 1, 1726, and the remaining twenty-five at such times as the management should consider it convenient to make a "call."

The shares seem to have found ready purchasers, who included persons of rank and distinction, even some ladies of the Royal Household. Yet the public press did not forbear to hurl at the enterprise many envenomed darts, tipped with such terms as "liar," "swindler," and "heretic"; the last, no doubt, most effective in the country of Torquemada and the Inquisition. It was probably owing to fears of priestly enmity that Wolters included in his lease a stipulation that any foreign employés of the Protestant persuasion should not be interfered with so long as they did not proselytise or air their opinions too openly.

In order to cut the ground from under the feet of his adversaries, Wolters did a very wise thing. Scarcely had the first instalments been paid on the shares when he appointed a mining engineer to

[1] Mr. W. R. Lawson, in "Spain of To-Day," assesses the capital at £375,000, assuming a gold doubloon to be equivalent to £3, 15s. But Mr. W. G. Nash, in his "History of the Rio Tinto Mine," puts the total amount much lower, at £20,000.

examine the mines and draw up a Report—just as is done to-day. The Report, for which an Englishman, Robert Shee, was responsible, said a great deal without giving much real information. It served, however, to quicken public interest greatly in the scheme, with results somewhat disastrous to the promoter, who soon found himself at variance with his fellow shareholders on pretty well every point which could be made the subject of dispute. The King, to whom reference was repeatedly made as umpire, finally decided, in 1727, that the company should be separated into two distinct enterprises: Wolters retaining the Rio Tinto and Aracena mines as his portion, while the mines of Cazalla, Guadalcanal, and Galaroza went to the other shareholders.

Wolters got the better half of the bargain, but at such a cost to his constitution that he shortly afterwards died, leaving his property to a nephew, Samuel Tiquet, also a Swede and a practical miner. Unfortunately, Tiquet became involved in a litigation suit with an Englishwoman, Lady Mary Teresa Herbert, who had lent money to the Company, and now sued it for breach of contract. The verdict went in her favour, and she entered into possession of all the five mines. But Tiquet, being a man not easily beaten, appealed against the decision, and was reinstated in his property, though not before the lady owner had played havoc with some of the mining and reduction plant. To the end of his life—he died in 1758—Tiquet continued an uphill struggle against

heavy odds. His successor, Francesco Tomas Sanz, fared equally badly, and the end of the lease found the Rio Tinto mine, with its fabulous resources ready to the pick, yielding a beggarly hundred tons or so of metal a year.

In 1777 the Spanish Government once more tried its hand at administering the mine, in order to get material for its bronze currency. But money was supplied to the management in such niggardly quantities that little progress could be made. The Peninsular War, which paralysed all industry in Spain, caused the abandonment of the mine for nearly thirty years. Then the Government, in 1828, offered the mining rights at auction for a period of twenty years. The highest bid came from a Frenchman, the Marquis de Remise, who offered £2600 per annum for the first ten years, and £3100 per annum during the remainder of the lease. He seems to have worked the mines with fair success, and certainly increased the yearly output to over 2000 tons.

When his lease fell in, the Government again took over the task of converting copper into cash, which they now sorely needed. Whether the Spanish official was radically incompetent, or was so enmeshed by red tape that common-sense mining practice proved impossible, we cannot say. Whatever the facts may be, the Government decided, in 1872, to sell the property which for centuries had been the source of endless squabbles, litigation, and loss.

We must now retrace our steps a few years to see how it came about that Spain found a purchaser of one of her greatest treasures. Mr. W. R. Lawson in his book draws attention to the fact that Napoleon III.'s *coup-d'état* in 1851 practically exiled many Frenchmen who took the anti-Bonaparte side. A large number emigrated to England. Others, of a more adventurous turn, crossed the Pyrenees into the land where, half a century earlier, the legions of the greater Napoleon had held temporary sway. Attracted by stories of Spain's mineral wealth, they sent men in advance to spy out the land and report. The forerunners passed southwards to Huelva, searching for the mines associated by legend with the Tarshish of Scripture; and after examining the Rio Tinto, which did not suit their fancy, fixed upon the "Tharsis" in a neighbouring valley. They obtained a lease from the Government and worked the property until bought out by a Scotch syndicate.

Another political upheaval, the American Civil War, led to a second invasion of Spain by fortune-hunters. This time they were Germans, whose livelihood in the States had vanished amid the clash of arms. A Mr. Doetsch became manager of the Rio Tinto; Wilhelm Sundheim started a shipping business at Huelva; while a Mr. Blum sat down and watched what was going on at Tharsis and Rio Tinto. His deep mineralogical knowledge soon caused him to recognise the true value of the immense copper lodes, and he gave his two friends his opinion

on the subject. At this time (1872) Spain had only just emerged from the Carlist war, in a state verging on national bankruptcy. It became absolutely necessary to realise such assets as could be changed into money ; and when a bill, drafted by Messrs. Doetsch and Sundheim, for the sale of the Rio Tinto mines by auction, was brought before the Cortes, it soon received ratification. On February 14, 1873, the tender of some English bankers, Messrs. Matheson & Co., of £3,712,000 was accepted, and the Rio Tinto passed into the hands of an Anglo-German group of financiers.

The enormous price paid for a property which, considering its now ascertained value, can scarcely be said to have been more than scratched, may seem to mark a gamble of unprecedented proportions. Yet the purchasers were hard-headed men, who, though they took risks, did so with their eyes very wide open, and not until the lodes had been fully reported upon in a manner somewhat more scientific than that of Wolters' expert.

The confidence placed in the reports was fully justified. At first shareholders who had bought in a hurry sold as hastily—£10 shares going for thirty shillings. They were glad to repurchase at £30 ; and to-day the shares are worth more than £60, despite the immense sums that have been spent since the purchase on railways and dock accommodation at Huelva.

The Rio Tinto is undoubtedly the largest mine in

the world. It covers eight square miles, and gives subsistence to 50,000 people. It is worked by tunnelling and also by the "open-cast" system, which merely clears off the "overburden," or useless earth, &c., and quarries down into the deposit. There are hills through which cross-cuts have been driven for 250 yards without emerging from solid ore. "The area of the mine," says Mr. Lawson, "is covered from end to end with masses of red and grey earth looking like gigantic ash-heaps. A few of these are the natural hill-tops, which it has not been thought worth while to remove; but most of them are artificial mounds formed during the operations of the mine. That towering mass of broken slate and granite in the distance was made by the Romans, whose implements and domestic utensils are found in it to the present day. That high embankment of blood-red clay and porphyry, with two lines of railway running along the top of it, is 'overburden.' It represents millions of tons' weight, and has been carried miles away from where Nature placed it. In the hollow below there is as much slag or cinder from the blast-furnaces as would pave all London, and it is but a fraction of what the furnaces have turned out. Every year thousands of tons of it are put on the railway as ballast, and wherever a chance occurs it is made away with, but still it goes on growing. . . . Rio Tinto was wild and desolate enough when the copper miners laid hold of it; but that was grace and beauty compared with what it is now.

Pluto himself, lurid as his fancy is supposed to be, could not have conceived the idea of such a scorched, scarified, and grimy wilderness as it has since become. It is pandemonium painted red and set out to roast in a blazing sun. . . . The terraces (of the open-casts) are traversed by nearly sixty miles of railway, on which more than thirty locomotives and 750 waggons are running daily. From one end of the workings to the other is a journey of seven or eight miles, curving in and out of hollows, crossing points, running up one slope and down another, and your engine all the while shrieking to signalmen at every few hundred yards. Walking is out of the question in such a country. Short journeys the superintendents do on horseback, but for long ones they have to take the rail. When they wish to look round, instead of calling a hansom, they send for an engine and car. It takes them quickly over the ground and gives them a good elevation to see from." [1]

The copper forms but a small part of the ore. Sulphur [2] is present in large quantities, also iron. Only the richest ore is smelted on the spot. A considerable portion of the ore is taken direct from the mine to ships at Huelva, whence it travels to England and other countries. Some, again, is reduced by "calcination," ready for the smelter, and so shipped. One of the most lucrative processes is that

[1] "Spain of To-Day" (Blackwood), pp. 99, 100, 101.

[2] Sulphur is a valuable asset; nearly 120,000 tons of the chemical left the mines for export in 1901.

of precipitating the metal from water which has been allowed to pass through heaps of refuse and "smalls," or dust ore. In fact, no mining industry is more complex than that of separating copper from its matrix. This partly accounts for the high price of copper—about one-fiftieth that of silver, which for years past has steadily depreciated. The world's demand for copper is in advance of the supply, largely because of the immense quantities of the metal used in electrical equipments. It would be a great boon to civilisation if the price were halved, while still leaving a sufficient margin for the producer to make mining a profitable business. As time progresses, improved and economical means of reduction are discovered, but at present there appears to be no parallel between the copper and steel industries in this respect. Copper mining is also hampered by the great cost of dragging the ore from depths seldom reached in connection with other minerals.

The future welfare of Spain is bound up with the advance of agriculture and the further tapping of her mineral wealth. The Saracens were tillers of the soil and converted many barren stretches of sandy desert into well-watered gardens; and to-day the eastern provinces are noted for their fertility and high cultivation. Though agriculture must in all countries be the foremost industry—that one upon which the health as well as the wealth of a nation must depend—mining comes in a very good second

as the provider of riches. And it is for this reason that future generations should witness a great change in the Peninsula. As soon as the internal condition of the country is such as to attract foreign capital in larger measure than to-day, railways will be run through hundreds of districts now far removed from the sound of the locomotive's whistle. The examples of Rio Tinto, Almaden, and Bilbao, will lead to a hundred other enterprises among the gold, tin, lead, coal, and silver deposits which are waiting to make Spain one of the richest kingdoms of the world—when the Spaniard is ready to turn from his old-time doctrine of manaña—"to-morrow"—and lay his hand to the splendid task before him. We may live to see Spain once more the greatest mining country of Europe, such as it was when the Romans sent their thousands of slaves to work their wretched bodies to death in the horror-chambers of the Sierras; such as it was when, a thousand years earlier still, the Phœnicians sent their ships from Tyre and Sidon to fetch treasure from near the Pillars of Hercules.

CHAPTER XIV

OTHER FAMOUS COPPER MINES

The copper contributions of different countries—The United States—The Lake Superior deposits—History of their discovery—A large mass of solid copper found—Sensational blocks of metal—The Calumet and Hecla Mine—A huge shaft—Machinery at the mine—Refining—A bad speculation—The Montana deposits at Butte—The Anaconda Mine — Bessemerising copper — Arizona — California — The copper mines of Ashio, Japan—Fahlun—Rammelsburg—Splitting rocks with fire—The Burra Burra Mine—British copper mining—A decayed industry—The Parys Mountains, Anglesea—Concluding remarks.

At the present time the United States produces far more copper than any other country. While Spain yields about 50,000 tons annually, Mexico 40,000, Australasia 29,000, and Japan 30,000, the United States furnish 275,000 tons out of the world's total of about 525,000 tons. That is to say, more than half of all the copper mined comes from the land of the Stars and Stripes.

Three States take the lion's share of the copper industry. Montana heads the list with about 250 millon pounds' weight; Michigan comes second, with about 150 million; and Arizona third, with 115 million. At ruling prices the output is worth over 86 million dollars annually, a sum which gives copper the first place among metals in the United States after iron.

The most famous copper district in the New

Open-air calcination heaps, or "Teleros," at the Rio Tinto Mines. The ore is burnt in piles to get rid of water, sulphur, &c., preparatory to smelting in the furnaces.

World lies on the south shore of Lake Superior, in a tongue of land known as the Keweenaw Peninsula. Parallel to the water, a few miles inland, runs the Mineral Range, intersected by veins of the metal.

Before noticing individual mines we may glance at the discovery and history of these remarkable deposits.

The early exploration of the country bordering Lake Superior was undertaken by Jesuit priests, who played a very important part in Franco-American history of the seventeenth century. The frequent occurrence of copper was one of the objects that early attracted their attention, and its presence, so often met with among the Indians, naturally excited their curiosity and wonder. Repeated mention of it is made, and in some instances the descriptions relate to masses of considerable size. But long prior to this period, the metal that attracted the attention of the missionaries and early *voyageurs*, and which now forms the basis of a great industry, had been sought and mined for by a people who have left no record but the implements which they used and the excavations which they made. These excavations had been obscured from view by the slow growth of overlying *débris* during the years which had since elapsed, and the Indians had no knowledge of the workings of their prehistoric predecessors. In fact, no suspicion that any such mining had been done occurred until comparatively

recently, after the country had been settled and prospectors had commenced operations. Then it became known that the copper veins of the district had apparently yielded large amounts of metal to some forgotten race. That the old occupation of the lodes was very ancient was evident from many facts. Pits and tunnels had become filled with rubbish and overgrown with large forest trees. If depressions were ever observed, they were naturally regarded as those made by overturned trees, or as hollows in the rocks; and it was not suspected until the actual discovery, as late as 1847, that the district had once been busily mined. So general are the ancient excavations of the Mineral Range that there is scarcely a vein or outcrop in the whole copper district which does not bear signs of the old miners, some of them pits sunk fifty feet or more into the solid rock. In these pits, when cleared of rubbish, have been found large masses of copper which the primitive seekers had unsuccessfully tried to remove. Lumps of solid copper, weighing many tons, have been discovered surrounded by numerous stone hammers, pieces of burnt wood, and other evidences of former labour. It is obvious from the nature of these finds that the rock was heated and then split by pouring water on it to make it friable enough for smashing with the stone hammers, which consisted of small boulders of hard rock, weighing from three to thirty pounds, round which a groove had sometimes been made to hold an osier handle.

The old-time miner knew his business so well that modern prospectors have sought eagerly for these ancient pits, as betokening the outcrop of the copper lodes. In 1760 an explorer, Alexander Henry, found a great copper mass about twenty miles above the mouth of the Ontonagon River. Ten years later he took men with him and tried to secure the metal, but only managed to chip off some pieces. In 1820 General Lewis Cass, Governor of Michigan, led an expedition to the same spot. The party had great difficulty in ascending the rapids, and climbing over the mountains under a blazing sun, while harassed by countless flies and mosquitoes. The General became exhausted; but the others, pushing on, discovered the object of their search, which, though not so big as they had anticipated, was still considered a remarkable object. It had evidently been much reduced from its original size; and broken tools lying about showed that several persons had attempted to hew it to bits.

This mass of native copper—the largest that at that period had ever been found—was transported bodily down the river in 1842, and sold to the United States Government, who set it up in the grounds of the War Department at Washington. Its arrival caused quite a sensation among mineralogists, and soon the district from which it had come was swarming with speculators, prospectors, and explorers, all bent on tapping the mother lode.[1]

[1] *Vide* "Mineral Statistics of Michigan," 1880.

In the "Cliff" Mine other large masses were soon encountered, the first being struck in 1845. This discovery was of great importance, since it determined the fact that the erratic boulders previously found had their origin in the region itself. It was the precursor of a succession of masses that astonished the world and gave confidence to investors and enthusiasm to the workers. In 1852 a mass weighing 200 tons, 40 feet long, 20 feet wide, and 2 feet thick, was discovered in the North American Mine, close by. But a few years later this huge block was quite eclipsed by lumps found in the Minnesota Company's mine. Of one of these the engineer wrote: "It was at once apparent that they had something very valuable, but they had no conception of the immense thing which a few days' work disclosed. At one convenient point they broke away behind the copper so as to get in a sand blast of five or six kegs of powder. They stripped the mass further and again fired without result. Again they fired nine kegs of powder, and the mass remained unmoved. Breaking the rock round for a considerable distance, eighteen kegs of powder were shot off without effect, and again twenty-two kegs, and the copper was entirely undisturbed at any point. After further clearing, twenty-five kegs were shot off under the copper, and, it was thought, with some effect. But a final blast of thirty kegs, or 750 pounds, was securely tamped beneath the mass and fired. As soon as the smoke cleared away, a mass of copper forty-five

feet long and three to five feet in thickness, apparently very pure, and which will probably weigh *three hundred tons*, had been shot out and was ready for cutting up. It was torn off from other masses which still remain in the solid rock." A later report says: "There is now in the Minnesota Mine, between the adit and the 10-fathom level, a single detached mass of apparently pure metallic copper, which is some forty-five feet in length, and in the thickest part as much as eight or nine feet in thickness. It contains probably more than *five hundred tons* of pure metal, and is worth, as it lies, more than 150,000 dollars."

It took twenty men *fifteen months* to remove this monster, which had to be hewn asunder as it lay. Some of the cut faces measured sixteen square feet, and the mere chips weighed over twenty-seven tons. Truly a splendid find—the largest and most valuable "nugget" ever struck by miner!

Among the Michigan copper-mining companies, that known as the Calumet and Hecla stands preeminent. It produces more than half of all the Keweenaw metal; and is further remarkable for the fact that it rivals the neighbouring Tamarack Mine in possessing the deepest shafts in the world. "In all the estimates and considerations applicable to other mining companies this mine must be excepted. The mine so exceeds all others in extent and richness that there is none to be compared with it in product or in profit. If any comparison is instituted it must be borne in mind that the Calumet

and Hecla lode is probably by far the richest vein ever known in the annals of copper mining."[1]

The mine is situated about five miles from the shores of Lake Superior, and about twelve miles from Portage Lake, with which the Mineral Range Railroad connects it. The Calumet Company was started in 1865 with shares that stood at a dollar apiece. But the profits were so large that the price rose rapidly to thirty dollars, and a few months afterwards to seventy-five dollars. In 1871 the Hecla Company, which was working close by on the same lode, amalgamated with the Calumet, and the two ventures have since been run as one very successful concern. Within three years of joining forces dividends of 2,800,000 dollars had been paid on the total capital of 1,000,000 dollars! By 1881 dividends aggregated nearly 19,000,000 dollars, and enough money had also been spent to instal mining plant superior, it is believed, to that of any other mine in the world.

Everything here is on a gigantic scale. The Red Jacket shaft is known, by name at least, to mining engineers all the world over. This was begun in 1889, and for twelve years men worked on it night and day, until a huge well, 4900 feet deep and 14 by 22½ feet in section, had been driven down through the rock and copper-bearing conglomerate. One and a-half million cubic feet of material were removed, with the aid of power drills and dynamite;

[1] "Mineral Statistics of Michigan."

and the excavation was lined from top to bottom with pine, besides being divided into six separate compartments. The amount of timber needed for the work was enormous: enough to represent the destruction of a large forest. The shaft is so constructed that in case of fire in the mine the men can make their escape through it when all other means of exit are cut off. Two disastrous fires in 1887 showed that it was necessary to make provision for similar accidents in the future. Hence this great work, the magnitude of which will be more fully realised if you consider that five Eiffel Towers piled one on the top of the other would not total in height the depth of the shaft!

In addition to the Red Jacket, the Calumet and Hecla Company can boast no fewer than eleven shafts averaging about a mile in depth. Through them the lode is worked horizontally for a distance of two miles.

For hoisting from such depths great speed is necessary to avoid undue loss of time. Two huge engines dominate the top of the Red Jacket, up which they whirl the cages at a rate of nearly twenty miles an hour. They form one of the most striking features of the whole plant. "The twin engines — the Minong and Siscowit, as also the Mesnard and Pontiac—are the finest engines on the mine. The two latter are held in reserve in case of accident; and here it might be said that the Calumet and Hecla have duplicated every engine on the mine.

Some idea of the size of the engines at the Red Jacket shaft may be gained from the weight of some of their parts: Engine bed, 76,100 lbs.; main pedestal bed-plate, 150,722 lbs.; end-piece for bed-plate, 19,466 lbs.; cylinder, 25,500 lbs.; engine beam (steel), 64,920 lbs."[1] To ventilate the mine huge Guibal fans, thirty feet in diameter, pour air down the shafts all day long; and to work pumps and drills high-pressure air is forced down through many miles of piping. As at the De Beers mines, Kimberley, "Forwards" is a word which the engineers are very fond of; and when any improvement in machinery appears they soon adopt it for their own uses. Consequently, the mining student can hardly find a better school in which to learn his trade than the domains of the Calumet and Hecla.

The ore mined is very equal in quality, though it contains only three per cent. of copper. Huge masses of solid metal are not found at extreme depths. But as the vein is in places thirty feet wide, it can be worked economically. Indeed, copper being so extremely tough, the dismemberment of large solid lumps might be even more costly than the reduction of comparatively poor ore. Owing to the perfection of the machinery used, ore containing only a few pounds of metal per ton can be treated profitably.

The levels, or galleries, are 100 feet apart vertically.

[1] *Cassier's Magazine.*

Large gangs of miners blast and chip the ore from the "stopes," or blocks, formed in the vein by vertical and horizontal channels cut through the vein right across its breadth. The "stuff" is dumped into cars, each of which holds three tons; the cars are run into cages in the shafts, and soon reach the surface. There the ore passes into a crushing plant, which smashes it until no lump has a diameter exceeding six inches; and then is despatched to the stamp mills at the Lake's edge. These can each reduce upwards of 500 tons of ore per diem to the size of small marbles. The rubbish is washed out by apparatus somewhat resembling the separators described in connection with the Rand gold mines, and the residue goes straight to the smelting furnace, since the ore is singularly free from those chemical impurities which in other districts, such as the Rio Tinto, render copper reduction a very complicated business.

The furnaces used are of the *reverberatory* type. The ore lies in a shallow dish-shaped chamber of fire-brick, and the flames of the furnace in an adjacent compartment pass over the top of the intervening wall and are deflected down on to the ore by a roof of very refractory (*i.e.* fireproof) material. The slag and scum is skimmed off, and the molten mass is kept stirred through openings in the sides of the hearth. When scum ceases to appear, the copper is ready for tapping, and is run off into ingot moulds. "Lake" copper is famous for its high quality. At the lower

depths the percentage of arsenic in the ore increases, and to get rid of this unwelcome element economically the Calumet and Hecla people send a lot of their stuff to refineries at Buffalo.

Though many extraordinary successes mark the copper-mining history of Michigan, there have been equally gigantic failures. To any one coming to the Keweenaw Peninsula, and seeing the amount of ore raised from hundreds of shafts dotted about here, there, and everywhere, it would appear probable that other shafts sunk in their immediate vicinity must sooner or later strike ore. But that such conclusions, if acted upon, sometimes have unexpected and unpleasing results, may be well illustrated by the case of a Philadelphian syndicate, which some years ago bought up large tracts of land in the Keweenaw, and made preparations for a campaign which would take the wind out of the sails of some other big concerns. So confident were the promoters of success that, while their huge shafts were piercing the earth, they built the finest stamp mill in Michigan ready for the ore that would presently pour up from the workings. They also went to the expense of a private railroad connecting mine and mill; and dug a canal from the mill to the Lake.

But alas! the experts for once had made a lamentable miscalculation. The winding engines puffed and panted, the rock drills bored, dynamite rent the rock. The miners toiled on, looking for the colour which would tell them that their labour had

not been in vain. Thousands of tons of useless, barren stuff came up in the skips. The managers wore a look of increasing anxiety, when the level at which ore should have shown had been passed and still there was no sign. At last the terrible fact could no longer be denied, that tens of thousands of dollars had been flung into the pit beyond hope of recovery. The engines ceased to turn, the miners sought work elsewhere, and now the rust-eaten machinery and the massive buildings stand as a warning against over-confidence.

The copper-bearing district of Butte, in Montana, has been exploited over an area not exceeding two square miles. Yet from this small block comes nearly half of the metal mined in the States. The Anaconda Mine is to Butte what the Calumet and Hecla is to Keweenaw.

Vertical fissures in the granite, varying in breadth from a few inches to a hundred feet, have been filled by Nature's laboratory work with a compound of silica, iron pyrites, sulphur, and copper. Silver also occurs in the proportion of two to six pounds per ton of ore, and there is a very small percentage of gold.

Large caverns are dug in the ore bodies and timbered on the "square-set" principle used at the Comstock and at Leadville. Ore is raised in ten-ton skips and sent by rail to the great reduction works at Anaconda, where a huge plant, capable of handling 5000 tons per diem, covers sixty acres. After being

crushed between huge rollers and washed, the ore goes to the mechanical roasters, which drive off water, and some sulphur, and leave material fit for the furnaces. These eliminate more of the impurities, until the residue, about one-half copper, is ready to be run into iron tanks carried on rails, transferred to the converter, and treated by the Bessemer process, air being blown through the liquid copper to drive off more sulphur and cause the iron present to combine with the silica which lines the converter. The converter, which swings vertically on two trunnions, or pins, and somewhat resembles a champagne bottle with the top of the neck cut off, is tipped over till the charge can be poured in through the narrow mouth at the top. Then the air-blast is turned on. Thousands of cubic feet of air rush through the molten metal, and cause a greenish flame to roar from the mouth. The iron combines with the lining, to form slag, while part of the sulphur present passes off as sulphurous acid gas. By the time that the process is complete, and the slag has been removed, 99 per cent. of what remains is copper.

To separate any gold or silver carried by the copper, electricity is used. The metal is first cast into large plates, which are immersed in a chemical bath and connected with the one terminal of a strong electric circuit, which deposits the copper on a second plate, also in the bath, connected with the other terminal of the electric circuit, and allows the

more precious elements to sink to the bottom of the tank in the form of mud, which is afterwards refined. This method of reduction is much more complex than that which circumstances permit at the Calumet and Hecla; though by no means so intricate as is the series of operations necessary with some other very impure copper ores.

Arizona, the third great copper State, could once, like Michigan, boast many rich surface deposits—found in caves in the limestone—consisting of very beautiful blue and green crystals, called azurite and malachite, which contained in some cases 25 per cent. of copper. So profitable was the smelting industry, in spite of difficulties in getting a good supply of fuel, that the smelters did not hesitate to cast aside slag carrying 2 to 3 per cent. of metal; richer, that is, than much of the ore to get which such enormous shafts are sunk in Michigan. The United Verde mine, at Jerome, is the largest copper mine in the world owned by a single person. As it produces 20,000 tons a year, and as the copper contains enough gold and silver to pay all costs of extraction, the proprietor, Senator W. A. Clark, ought to be a wealthy individual.

California, though so rich in other minerals, can claim but one copper mine of importance, that of Shasta. Her annual production is about 15,000 tons. Tennessee mines about half this quantity.

Turning to other countries, we find that Mexico takes a leading place as a copper yielder. The

Boleo deposits in Lower California are the most valuable. Chile has in half a century produced over 2,000,000 tons; but at present its output tends to decrease. Thirty-five years ago Chile furnished half the world's supply of copper. Japan, on the other hand, is coming to the front. The development of Japan's natural resources has been as remarkable as her increase in military power. Though sulphur, gold, and copper have all been worked by the "gentle Japs" from time immemorial, the methods employed were, till lately, very primitive. When, in 1853, Japan abandoned her policy of isolation, and gladly welcomed Western ideas, mining at once went ahead. To-day she produces 30,000 tons of copper, a large proportion of which is exported to China and Korea for minting purposes.

Japan's great copper district is that of Ashio, near Nikko, in Hondo, a town which tourists visit on account of its fine scenery and magnificent shrines. From Nikko the mines may be visited in jinrickshaws. "Tea-houses along the route exhibit beautiful specimens of copper pyrites, which are sold to pilgrims to the sacred mountain of Nai-tai-san (close by), and the traveller is also notified of his proximity to the copper mines by the tramcars passing through the streets of Nikko, drawn by slow-moving bullocks, laden with copper ingots on the down trip and returning with fuel. The change from Nikko is complete. One leaves a land of peace, with delightful surroundings, and steps into the midst of a foul-smelling, smoke-

laden valley, where the bare red hillsides, denuded of all vegetation, present a striking contrast to the green hills of Nikko, with its world-famed avenue of cryptomerias, while the air vibrates with the clang of hammers and the throb of engines."[1]

The writer whose words are here quoted goes on to say that the village of Ashio has flowing through it a stream spanned by numerous bridges of designs so different that the visitor is left with the impression that the "engineer-in-charge" must have "put into practice all the available literature of bridge designing." Over 10,000 people are employed in the copper industry here, a large number of whom had never seen the country lying beyond the red encircling hills till the Great War gave them the signal to join the contingents hurrying to meet the Russians in Manchuria.

The village has a well-equipped hospital at which the miners and their families are treated free of charge. Only men work below ground, their womenfolk finding employment in the sorting and washing of ore. The pay is sevenpence a day, and a small allowance of rice and fuel; though the more skilled mechanics earn fifteenpence. Not a very tempting remuneration as judged by western standards!

The mines are entirely managed and organised by Japanese. Yet they are equipped with up-to-date machinery and appliances throughout—reverberatory

[1] *The Engineering Magazine*, October 1901.

furnaces, electric light, electric cars, a thirty-mile railway, and a three-mile cableway over the mountains for transporting copper ingots and fuel. The ore is very rich in metal, which averages about 20 per cent., so that, with labour as cheap as it is, Japanese copper must prove a formidable competitor to that produced where the percentage is lower and labour much more expensive. Though originally the property of the Japanese Government, the mines are now owned by a single proprietor, who, like Senator Clark, must be well on the road to millionairedom, if he has not already reached that desired goal.

Other famous copper mines are those of Fahlun in Sweden, said to have been explored before the Christian era. At their most prosperous period they yielded 5000 tons of metal yearly, besides large quantities of lead. Then there is the celebrated Rammelsberg deposit of the Harz Mountains in Germany, which is like an inverted wedge, the thickness of the vein increasing as it descends. It has been in operation for nearly a thousand years, and at one time produced very abundantly. It was for a long period worked on the "open-cast" system, like the Kimberley mines in their earlier days, but when the depth of working became great, recourse was had to shafts and galleries. A writer thus describes the method of softening and splitting the rock by fire which the German miners employed in the middle of last century. "By a fixed plan, piles of faggots are arranged in the mine, and it is usually on a

Saturday that all the piles of faggots distributed during the week are kindled. Those in the upper floors are first burned, and kindled in the upper ranges at four o'clock in the morning, from pile to pile, and very soon the fire unfolds its wings in the metallic vaults, which are filled with vast volumes of smoke and flame. In course of time the ores pass into a shattered and divided condition, which allows them to be afterwards detached by long forks of iron. The combustion goes on without any person entering the mine from Saturday evening to Monday morning, when the fireman and his assistants proceed to extinguish the remains of the bonfires. On Tuesday all hands are employed in detaching the ores, sorting them and taking them out, and preparing new piles of faggots against the next Saturday."

The Burra Burra Mine of South Australia was a wonder of the decade preceding the "gold rush." It yielded richly from "open-cast" workings for nearly thirty years, and paid a million sterling in dividends. It has now been worked out.

Want of space forbids more than a mere mention of the deposits of Canada, Namaqualand, Siberia, Bolivia, and the Caucasus; but before concluding this chapter we may glance at the copper industry of Great Britain, once responsible for half the world's total output, but now shrunk to meagre proportions. To-day the British Isles produce only 650 tons annually, a sad fall from the 20,000 tons of 1863.

Cornwall and Wales mine most of this scanty quotum; though a hundred years ago the Parys Mine, Anglesea, was the chief source of copper.

This is how Mr. Richard Warner describes the scene at the Parys Mine in 1799. "This vast natural accumulation of mineral, which measures a mile in length and half a mile over, rises to the south-east of the town [Amlwch], about two miles from it. Its appearance is waste, wild, and barren in the extreme; not a vestige of green is seen on its parched and scarified surface, all vegetation being prevented by the sulphurous fumes which arise from the roasting heaps and smelting-houses and extend their destructive effects for miles round. . . . The wonders of this abyss [the open-cast] are not concealed by a superficial crust of earth, but all is open to the day. The bowels of the mountain are literally torn out, and the mighty ruin is subjected to the eye. Standing on the edge of the excavation, the spectator beholds an awful range of huge caverns, profound hollows, stupendous arches, gloomy passages, and enormous masses of rock. Amid this striking scenery the miners are engaged in their curious but perilous occupations; some sticking to the sides of the rock, or seated on the narrow ledges of precipices, which gape beneath them to the depth of two or three hundred feet, tearing the ore from the mountain, and breaking it into smaller masses; others boring the rock in order to blast it, whilst a third party are literally hanging over the abyss below them, drawing

up and lowering down the ore-buckets, supported only by a frame of woodwork, which quivers like an aspen leaf with the operation carrying on upon it. Ever and anon we heard loud explosions rattling through 'the dark profound,' occasioned by the discharge of the gunpowder, and in separating the ore from the mountain. The reports varied, increased, and multiplied amongst the passages and caverns of the abyss, and, united with the scene of rocky ruin below us, excited the idea of the final consummation of all things."

This huge deposit, whence 5000 tons of copper were once got annually, has now been so exhausted that Anglesea yields only 27 tons a year, and that amount is extracted from the water flowing out of the old workings.

One striking feature of copper mining is that, though the metal is widely distributed, and mined in most countries, a very large part of the world's total output comes from but a few mines. These—the Calumet and Hecla, the Anaconda, and the Rio Tinto—between them account for 28 per cent.; and eight—those mentioned *plus* the Boston and Montana, United Verde, Mansfeld, Copper Queen, and Tharsis—for 50 per cent. The *Engineering Magazine* thus sums up the question of future supplies of copper: "The dominating position taken by the United States among the contributors to the world's supply of copper has already been commented on. The immense activity of the Americans, added to their

mechanical genius, has led to the initiation by them of a scale of operations hitherto unprecedented in the history of mining. But, if the increasing demand for copper continues, present sources of supply will soon be insufficient, unless production at the big mines can be still further stimulated. It is doubtful, however, whether the production of mines like the Anaconda and the Rio Tinto can be very largely increased. And there is another side to the question that must not be lost sight of—the more rapidly an ore-deposit is exploited, the sooner it will be exhausted. It is true that there are immense reserves of copper ore at Lake Superior, assuming that the beds can be profitably worked down to a vertical depth of 6000 to 7000 feet ; but it seems likely that even this source of supply will fail to cope with the increased demands of the early part of next century, and three or four decades will probably see it exhausted. We are bound to assume, therefore, that unless new and abundant sources for the metal are opened up in the early part of next century [the twentieth], or some substitute is found for it in the electrical industry, there is no prospect of copper being over-produced."[1]

[1] April 1900.

CHAPTER XV

QUICKSILVER MINING

Characteristics of quicksilver—Its uses—Cinnabar—Almaden—Its early history—The workings—Dangers of quicksilver mining—Poisoning—New Almaden—Its discovery—Ill success of first company—Separation of metal from ore—Description of the mine—The miner—The carrier—Sorting the ore—Injuries to health—Mexican mining superstition—Figures relating to New Almaden.

A PECULIAR characteristic of quicksilver, or mercury, distinguishing it from other metals, is its extremely low melting-point, which is 38 degrees below zero, Fahrenheit. At ordinary temperatures it is always liquid, and on account of the consistency of its rate of expansion when heated, it is invaluable in thermometers, excepting in such instruments as are called upon to register extreme cold, for which alcohol is used instead.

As its melting-point is low, its boiling, or vaporising, temperature is comparatively low also—to be exact, 675.1 degrees Fahrenheit. This property, in conjunction with a readiness to combine with gold and silver, makes mercury play so important a part in the refining of precious metals. We have already noticed, in our chapters on gold and silver mining, how it is spread in sluices, vats, and patios to seize upon finely divided gold or silver and form an

amalgam with it, out of which the more volatile metal is easily driven by the action of heat, to be caught in cooling chambers and condensed back to liquidity.

Apart from metallurgy, quicksilver is valuable to the maker of many scientific instruments: to the electrician, to the paint manufacturer, and to the doctor, who finds compounds of mercury most useful in the treatment of certain skin diseases and inflammation of the joints.

Mercury has a high specific gravity. Only gold, platinum, and iridium, among the better known metals, are heavier. It weighs, bulk for bulk, more than a third as much again as silver, and is nearly double as heavy as iron; so that an iron bar would float like a cork in a tank of mercury. Another feature is its freedom from oxidisation on exposure to the air.

Mercury occurs naturally as a sulphide called cinnabar, a red substance which is found in comparatively few parts of the world—Spain, Illyria, California, Russia, Italy, and Mexico. The best quality of cinnabar contains about 86 per cent. of mercury to 14 per cent. of sulphur.

The oldest and most famous quicksilver mine in the world is that of Almaden, in the Sierra Morena, almost at the meeting point of the provinces of Ciudad Real, Badajoz, and Cordova. The railway from Madrid to Cordova passes through the town, which has a population of about 10,000 people,

almost all connected directly or indirectly with the mines. The word Almaden is Arabic, signifying "The Mine of Quicksilver." Ever since the time of the Romans, who called the place Cisapona, Almaden has been renowned for this metal, which is mentioned by Theophrastus, Vitruvius, and Pliny. The last writer tells us, in his "Natural History," that the mine was sealed with the greatest care, and was only opened to take out the quantity of cinnabar necessary for the consumption of Rome, where it apparently served as a rouge for fashionable matrons and a pigment for painters.

The Moors did not work the mine; but after their departure it was reopened, and in the seventeenth century two Germans, Mark and Christopher Fuggar—softened by the Spaniards into Fucares—undertook to work the mine and give the Government 450,000 pounds of metal yearly in return for the mining rights. After some years of working they professed to be unable to pay the royalty on account of the exhaustion of the deposits, and withdrew in 1635, though not before they had amassed sufficient riches to make their names synonymous with millionairedom. A branch of the family took over the mine and worked it for ten years, when it passed again into the hands of the Government. Their manager, Don Juan Bustamente, established twelve furnaces, named after the twelve apostles, for reducing the ore; but on his being unable to make the mine pay the locality was explored for other deposits,

and this led to the discovery of the extraordinary formation that has been worked ever since. Until the deposits of New Almaden, in California, came to light in 1845, the Spanish mine was without a rival, and even now holds its own. To the world's total output of 3775 metric tons in 1899 Almaden contributed 1357 tons, or more than one-third.

There are three veins at Almaden, named the San Nicolas, the San Francisco, and the San Diego, running, as a rule, nearly parallel to one another, though they converge and meet at intervals. The principal vein is 25 feet in thickness, and though mined to a great depth, its richness and quantity seem to increase.

The town lies over the mine, which is entered by an adit or tunnel. Deep shafts penetrate into the bowels of the earth, ladders reaching from stage to stage. The pumping out of water, fortunately not a serious item here, was for years performed by machinery installed by Watt in 1790, and accounted a marvel of its day.

The mineral, hacked out of the veins by hundreds of semi-nude workmen, is hoisted up perpendicular shafts, and the metal is separated from its ore by distillation. The mercury is then poured into iron flasks containing 76½ pounds each, and the iron corks are screwed down very tightly by machinery, so that there may be no tampering with the contents.

Though the mine is very well organised—many of the galleries being arched over with masonry as

a protection against falls—the workers have a far from pleasant task to perform, on account of the injurious effects of mercury on the human constitution. Work in the Almaden Mine is so unhealthy that up to the end of the eighteenth century only criminals were employed as miners there. "Almaden," says M. Simonin,[1] "was the site of a *presidio*, or house of correction, and a gallery ran from the prison to the mine. Now the workmen, numbering some 4000 to 5000, are all freemen, attracted from all parts of Spain, and even from Portugal, by grants of land and immunity from certain civic duties, as the mine is a Government concern.[2] The miners are divided into three watches, each of which works about six hours out of the twenty-four, the rest being from ten o'clock at night till four o'clock in the morning." "The health of the men employed in extracting this most unwholesome mineral" (we quote here Captain S. E. Widdrington's "Spain and the Spaniards") "varies very much, but on the whole they are very seriously affected by the exhalations and the heat of the lower workings. This may easily be imagined when it is stated that at the lowest part to which we descended the quicksilver was running down the walls, and the heat was considerable, whilst the ventilation was naturally extremely deficient. Both Doctor Daubeny and myself sensibly felt the effect even in the short time

[1] "Underground Life."

[2] And a very valuable asset, one of the few real sources of income which the Government possesses. About £250,000 worth of metal is raised annually, and of this about £160,000 is clear profit.

we passed there, and I distinctly perceived the coppery taste of the mercury on the palate; how much more must the labourers be affected who are working hard, are heated, and almost naked! . . . After the winter's work most of them are seriously altered in health and appearance, but the effect of their native air soon restores them, and in most instances they return again. Everything depends on care and attention to diet; those who live freely, especially those who indulge in wine, rapidly fall victims to the disorders generated by the pernicious mineral, whilst those who are attentive in cleansing their persons immediately after leaving work and live temperately, using a good deal of milk, attain the usual age of man in that country. Some instances of men of upwards of seventy were pointed out who had worked all their lives in the mine, and were hale and strong, but these are rare examples."

M. Simonin[1] draws a rather darker picture. He says that few of the miners escape the effects of mercury. They become emaciated and wan, their gums are "salivated," and their teeth fall out, causing all the digestive troubles connected with defective mastication. They are subject to tremblings and convulsions, and finally die of consumption or become idiotic. Even the vegetable life of the district is affected by the mercury fumes, and the immediate neighbourhood is as sterile as the environs of the Rio Tinto.

[1] "Underground Life," p. 463.

Quicksilver Mining

The New Almaden mines are situated fifteen milcs from San José, in California. The first discoverers of the cinnabar deposits were the Indians, who found that, when mixed with grease, cinnabar made a very effective red paint for the decoration of their persons.[1] In 1845 a Mexican cavalry officer, named Castillero, met a tribe of Indians whose faces were painted with vermilion — the pigment made from cinnabar—and offered them a reward if they would reveal the spot from which they had obtained their paint.[2] When shown the place, he experimented, and being satisfied that there was a rich vein of the mineral, he registered a claim in accordance with the requirements of Mexican law, and communicated the news to a brother, who managed to raise enough money to form a syndicate for exploiting the mine. The first company, finding that the process of raising ore and extracting the metal was very expensive, gave up independent operations at the end of a year, and leased their rights to a second company, stipulating that they should receive one-fourth of the proceeds. Eventually, all the original shareholders were bought out by their successors,

[1] The paintings of an Indian's face correspond to the white man's crests. When an Indian puts on his full war paint, he decks himself not only with his own individual honours and distinctions, but also with the special honours of his family or tribe. Much interesting information on this subject will be found in *Pearson's Magazine*, December 1900.

[2] The aborigines had worked a tunnel fifty or sixty feet into the mountain side with sticks and stone hatchets. Among the *débris* at the end of the tunnel were found a number of skeletons, the remains of diggers who had probably been crushed by a caving-in of the roof.

who in 1850 had already spent £80,000 over and above their receipts. Fortunately, in that year an employé discovered a process of smelting the ore which greatly reduced the expense of extraction. An ore chamber, having two sides built of perforated bricks, is filled with cinnabar, and a fire is lighted in a compartment adjacent to one of these sides. The flames, passing through the ore, vaporise the mercury, which is carried along with the products of combustion through the other perforated wall into a series of condensation chambers, the partitions between which are open alternately at the top and bottom, and is condensed into metal. Any vapour that escapes the last condensing chamber passes over a cistern of cold water and through a spray of water. The metal runs to the lower end of each chamber, and thence through a small pipe into a trough extending to a large circular vat, from which it is drawn off into flasks.

The entrance to the mine is at the top of a steep hill, through a tunnel ten feet wide and ten feet high, which has been driven more than 1000 feet through solid rock to meet the main shaft. Along this runs a railway for cars, into which the ore is dumped as fast as the *tenateros*, or ore-carriers, can bring it up in bags of hide. This entry saves the carriers a great amount of labour, for, until it was made, every ounce of material, including useless rock, had to be transported an extra 150 feet perpendicularly to the top of the main shaft.

At the end of the tunnel is a shrine, at which every workman pays his devotions before descending to his round of labours. "You descend a perpendicular ladder, formed by notches cut into a solid log, perhaps twelve feet; then turn and pass a narrow corner, where a frightful gulf seems yawning to receive you. Carefully threading your way over the very narrowest of footholds, you turn into another passage black as night, to descend into a flight of steps formed in the side of the cave, tread over some loose stones, turn round, step over arches, down into another passage that leads into many dark and intricate windings and descendings, or chambers supported by but a column of earth; now stepping this way, then that, twisting and turning, all tending down, down to where, through the darkness of midnight, one can discern the faint glimmer which it seems impossible one can ever reach. We were shown a map giving the subterranean geography of this mine; and truly, the crossings and re-crossings, the windings and intricacies of the labyrinthine passages, could only be compared to the streets of a dense city, while nothing short of the clue furnished Theseus by Ariadne would ensure the safe return into day of the unfortunate pilgrim who should enter without a guide.

"The miners have named the different passages after their saints, and run them off as readily as we do the streets of a city, and after exhausting the names of all the saints in the calendar, have com-

menced on different animals, one of which is not inaptly called *El Elephante.* Some idea of the extent and number of these passages may be formed when we state that sixty pounds of candles are used by the workmen in the twenty-four hours. Another turn brings us upon some men at work. One stands upon a single plank placed high above us in an arch, and he is drilling into the rock above him for the purpose of placing a charge of powder. It appears very dangerous, yet we are told that no lives have ever been lost, and no more serious accidents have occurred than the bruising of a hand or limb, from carelessness in blasting. How he can maintain his equilibrium is a mystery to us, while with every thrust of the drill his strong chest heaves, and he gives utterance to a sound something between a grunt and a groan, which is supposed by them to facilitate their labour. Some six or eight men working in one spot, each keeping up his agonising sound, awaken a keen sympathy.

"We step aside to allow another set of labourers to pass. There they come; up and up, from almost interminable depths, each one as he passes panting, puffing, and wheezing, like a high-pressure steamboat, as with straining nerve and quivering muscle he staggers under the load, which nearly bends him double. These are the *tenateros,* carrying the ore from the mine to deposit it in the cars; and, like the miners, they are burdened with no superfluous clothing. A shirt and trousers, or the trousers

without the shirt, a pair of leathern sandals fastened at the ankle, with a felt cap, or the crown of an old hat, complete their costume."[1]

The *tenatero* must be a strong fellow, for his load weighs up to 200 lbs., and he makes 40 to 50 journeys a day. He has learnt the proper method of carrying a load, viz., by a broad band passing round the forehead. The African natives and Tibetan tea-carriers adopt the same system of distributing the pressure over the muscles of the neck and back. For this hard labour he receives three dollars a day. The miner is paid by results, and the gang to which he belongs takes care that he keeps hard at work.[2] When the ore has reached the surface it is spread in a yard, where labourers sort it over and break it up, separating refuse from the ore. The good stuff is then carefully weighed and loaded on mules—three hundred pounds to each animal—for transport to the furnaces.

In former times the cinnabar ore caused little injury to health. But at the depths now reached, where the ore is so rich that beads of metal as large as a pea can be seen clinging to the sides of the workings, the air of the *labores*, or stopes, is so saturated with quicksilver vapour that, in spite of good ventilation, the men suffer a great deal from metal poisoning. This is partly due to the heat of

[1] Mrs. S. A. Downer; quoted from "Scenes of Wonder in California," by James M. Hutchings.

[2] When a vein is broad and easily worked a miner makes £7 to £10 a week.

the workings, which causes profuse perspiration, and leads the miners to use very little clothing, so that the vapour has direct access to the skin. The effects are aggravated by the sudden changes from heat to cold, against which little or no precaution is taken by the ignorant Mexicans. More deadly even than hewing the ore is the drawing of refuse from the furnaces. Men employed in this business are obliged to knock off after three weeks of work, and to take a rest. Horses and mules also die from the effects of mercury poisoning.

It is remarkable that, while the Mexican recovers rapidly from wounds received in the frequent quarrels indulged in by the hot-headed natives, or from accidental injuries, he soon succumbs to constitutional troubles such as pneumonia and consumption. Mrs. Alec Tweedie[1] draws attention to the Mexican miners' prejudice against the presence of women in the mines. Should a lady visitor inspect the workings, and any mishap subsequently occur, such as the ending of a vein, or a fall of rock, it is at once laid at the door of the woman, who must have been the Devil in disguise! Managers are therefore very chary of allowing the fairer sex within their precincts, lest their employés should take fright and keep away for a day or two till the evil effects of the Satanic visitation might be considered to have evaporated.

The estate of the New Almaden Co. covers 7800 acres. Huge deposits no doubt still remain

[1] "Mexico as I saw it."

untouched. In the years 1850–67 this mine yielded 35,333,586 pounds of metal; and is still prolific enough to supply all the needs of New World miners, while leaving a good margin for export to China and Japan. In 1902 the value of the mercury raised from New Almaden and New Idria was about 1,500,000 dollars; and the weight 1195 tons.

Not worked now, on too low grades

CHAPTER XVI

THE TIN MINES OF CORNWALL

Cornwall—Its place in history—Phœnician tin merchants—The chief groups of mines—Nature of ore-seams—The Cornish miner—Mining feats—Carclaze mine—Botallack submarine mine—A storm overhead—The Wheal Wherry Mine—A persevering miner—*Carbonas*—Wheal Vor mine—Patience rewarded at Old Crinnis—Dolcoath—Getting out the ore—The man-engine—Treatment of ore—Uses of tin—Tin statistics.

OF late years, since railway communication has been extended and expedited, the isolated Duchy of Cornwall has become a favourite resort for holiday-makers, on account of its bold, rocky coasts, and the bright hues of the sea that washes them. A century ago the westernmost county of England was less visited by Englishmen than many foreign countries; since a journey to the rough promontory projecting far into the Atlantic involved more difficulties than a trip to Rome. While many other more accessible portions of our coast were still unhackneyed, unspoiled by hordes of invading trippers, there was little to attract folk across the Tamar into the land of saints, pasties, cromlechs and mines.

Not that Cornwall has played an unimportant part in English history. It was to Cornwall that the first voyagers of which we have record—the Phœnicians

—came to barter their wares for tin. In Cornwall the British made a long and desperate resistance to the Saxon invaders. William the Conqueror considered the district sufficiently important to form a handsome present to his half-brother, Robert of Mortain; and, owing to its riches and development, Edward III. created Cornwall a Duchy, which, since his time, has yielded its revenues to the Prince of Wales, or, failing a Prince, to the Crown direct. During the Civil War the Duchy naturally declared for the King, and the Cornishmen engaged in several fights with success.

As far back as records take us, mining has been the great industry of Cornwall. The earliest historical mention of our islands is made by Herodotus in connection with Cornish tin mining, if indeed the Cassiterides to which he alludes be the islands dotting the Cornish coast—and there seems little reason to doubt that they are. Diodorus Siculus, a Greek historian of the century preceding the Christian era, writes more explicitly: "The inhabitants of that extremity of Britain, called Bolerion, excel in hospitality, and, through their intercourse with foreign traders, live in a civilised manner. They prepare tin, working the earth which yields it with great skill. The ground is rocky, but has earthy veins, the contents of which are brought down, melted, and purified. After casting this into the form of cubes, they carry it to a certain island adjoining Britain, called Iktis. During the ebb of the tide the space

intervening is left dry, and they transport large quantities of tin to this place [probably St. Michael's Mount] in their carts. . . . From hence, then, the merchants buy tin from the natives, and carry it into Gaul, and at last, after travelling through Gaul on foot for about thirty days, they bring their burdens on horseback to the mouth of the River Rhone."

Besides tin, Cornwall has for ages yielded copper, granite, slate, lead, iron, antimony, manganese, and china clay. But the copper and tin mines are undoubtedly the most interesting features of the county. These two metals are sometimes found together in the same seam, either intermingled or in strata, as it were; though, as a rule, the lodes are worked definitely for one metal only. The chief groups of mines are as follows: (1) that of St. Austell, mostly tin-bearing, including the famous Carclaze mine; (2) that of St. Agnes, also stanniferous; (3) the Redruth, mostly copper-bearing, among which the Gwennap, Tresavean, Dolcoath, and United mines are the most notable; (4) the Marazion and Helston, including the Wheal Vor, Loe Pool, and Wheal Wherry tin mines; (5) the St. Just and St. Ives, mostly tin-bearing. The Botallack mine is the best known of this group.

Tin and copper are found in seams occupying faults in the granite and slate, the general direction of the lodes lying east and west. The veins vary in breadth from the thickness of a sheet of paper to many feet, and the ore is sometimes finely dissemi-

nated, and sometimes occurs in "bunches," or large masses. Copper is found in combination with sulphur, as a sulphuret or bi-sulphuret; tin in combination with oxygen, as an oxide. The tin seams were at some period largely disintegrated by the action of water, and their upper portions were washed down and deposited in the valleys to form the alluvial strata from which "stream" tin has been won in large quantities by a process much resembling the extraction of gold from surface "placers." The earliest tin mining was mostly "stream" work.

The Cornish miner is famous for his intelligence and resourcefulness. In all parts of the world where deep mining is conducted, posts of great responsibility are entrusted to the Cornishman, who, by both ancestry and training, is fitted to undertake any mining problem which requires skill and courage. As we have already noticed, Cornish copper mining has fallen on evil times, and though the tin mines still yield 5000 tons of metal a year, it is to the Straits Settlements that the world looks for most of its tin. Perak now exports annually the huge total of 46,000 tons, smelted from the ore of extensive stream works. As a consequence, Cornish miners have been obliged to emigrate in large numbers to seek a livelihood where their presence will be welcomed by the exploiters of virgin metal deposits; and many a Cornish village, once tuneful with the part-songs of its inhabitants, is unpeopled, and crumbles to ruin.

It must not be imagined, however, that Cornish

mining is a thing of the past. Many properties are still being steadily worked at a profit. Even were the country utterly deserted, there would remain the romance of great feats to which allusion must here be made. We should remember that Cornwall can boast some of the deepest and most extensive mines in the British Isles, and the early introduction of steam power to help drain the workings. Then there are the great drainage tunnels of Dolcoath and Gwennap, which rank high as engineering achievements. The Gwennap adit, emptying into the Carnon valley a little above the high-water mark, was begun in 1748 by the manager of the Poldice mine, and gradually extended in all directions until its branches drained fifty mines in the parish of Gwennap. One branch alone—that running to the Cardrew mine—is 5½ miles in length, and the aggregate of the excavations, which drain an area of over 5000 acres, reaches nearly *forty miles*. Think what labour must have been expended in driving these tunnels through solid rock without the aid of the power-drills and other modern appliances which the miner now has to help him! The feat even eclipses the making of the Nent Force Level, draining the Alston Moor mines, Cumberland, though this last is three miles long, and large enough for boats to pass through. As in the case of the great Sutro adit, the drainage tunnels of Cornwall can be used for the transport of ore.

The largest "open-cast" tin mine of the county is that at Carclaze, near St. Austell. "The enormous

open-work of Carclaze," says Professor Sedgwick,[1] "is an object of no ordinary interest. The traveller may there see the operations of the miner carried on in the light of day, without being compelled to descend a hundred fathoms below the surface of the earth, and then to crawl into a dirty dripping cavern." The ore deposit has been worked for nearly 500 years by generations of miners, who have scooped in the hills a huge bowl-shaped cavity, measuring a mile or more in circuit. Fifty years ago its dimensions were 1500 feet in length, 500 feet in width, and in places 130 feet in depth.[2] From this great excavation over a million tons of ore have been removed, yielding tin worth more than as many pounds sterling." "It is indeed a remarkable object when viewed in the whole, taking in its white cliff-sides of pointed abruptness, its self-contained completeness, its ever-widening extent, and the suddenness with which the whole is presented in one view to the stranger, with its men, women, and children scattered over the works. The ground which is laid open here is almost wholly composed of soft growan (decomposed granite), through which runs a numerous assemblage of schorl and quartz lodes in the usual direction. These, as they contain tin, are the sole objects of mining adventure, and the removal of the soft growan is effected by a stream of water, which conveys all the refuse of the mine through the adit. I believe

[1] "Cambridge Philosophical Transactions."

[2] *Vide* "Cornwall: its Mines and Miners," to which book the author is indebted for much of his information.

there is no other instance of a mine so worked, or of a mine the working of which is attended by so little labour."[1] We should add that much of the glory of Carclaze has now passed away.

Another famous mine is that of Botallack, situated on the "big toe" of Cornwall, not far from St. Just. Though copper forms the chief yield, tin and iron also are brought up from its depths. The entrance is at the edge of a cliff, from which a shaft runs obliquely through the *killas*, or clay-slate, to a depth of 240 fathoms beneath the sea. At many points horizontal levels have been driven in pursuit of the ore. Originally a perpendicular shaft 180 fathoms deep was used, but as it grew deeper the levels had to be driven farther and farther through barren ground to the submarine deposits. The proprietors therefore decided to cut the diagonal shaft, six feet square, through the *killas*, into the heart of the lode. The expense was great, but at that time large amounts of ore were being brought to bank. In Little Bounds and Wheal Cock, neighbours of the Botallack, the miners have worked upward so near to the sea bottom that only a few feet of rock separate the salt water from the galleries. During a storm the rolling of pebbles and thunder of the waves can be heard distinctly. "I was once in Wheal Cock," says Mr. W. J. Henwood, "during a storm. At the extremity of the level seaward, some eighty or one hundred fathoms from the shore, little could be heard of its

[1] "Cornwall: its Mines and Miners."

effects except at intervals, when the reflux of some unusually large wave projected a pebble outward, bounding and rolling over the rocky bottom. But when standing beneath the base of the cliff, and in that part of the mine where but nine feet of rock stood between us and the ocean, the heavy roll of the large boulders, the ceaseless grinding of the pebbles, the fierce thunderings of the billows, with the crackling and boiling as they rebounded, placed a tempest in its most appalling form too vividly before me ever to be forgotten. More than once doubting the protection of our working shield, we retreated in affright, and it was only after repeated trials that we had confidence to pursue our investigations."

If we admire the courage of men who are content to labour within so small a distance of destruction, what can be said of the adventurer who dared to sink a shaft from a point on the shore which was *covered at high water!* In Mount's Bay, near Penzance, were found, 140 years ago, some veins of ore crossing the Elvan Rocks. Miners excavated the outcrop during low tide, and even sank shafts to a small depth, protecting the tops by some method not recorded. In 1778 a miner named Thomas Curtis decided to make a bold attempt to erect permanent works over a spot where at spring tide the water is nineteen feet deep. His capital being only a few pounds, he had to execute the initial work single-handed, taking advantage of low tide to add a little more to the wooden tower which

very slowly rose twenty feet above the rocks, to which it was attached by means of stout iron stays. The joints between wood and rock were plugged with tarred oakum. The building of the tower and the sinking of a pump shaft occupied three summers. When this part of the work was completed, a platform was affixed to the tower's top, pumps were erected, and excavation for ore began. Curtis and his fellows—he had now got help—soon became aware that the rocks were fissured, and let in salt water, and that during a storm the tower leaked. Nothing daunted, the miners plugged the roof of their level with clay, and supported it with beams: though they found that during the winter it was impossible to work, owing to the difficulty of landing the ore in rough weather. In the summer months they made the best of their time, and drove a large level under the sea within a few feet of the surface, working eight hours a day. Thirty sacks of tin ore were brought out every tide, a quantity which yielded about one ton of metal. Curtis had struck a very rich lode, as indeed he deserved to do after his plucky fight with difficulties, and in course of time he made his fortune. Ore to the value of £70,000 was raised, and then, one day, ruin overtook the mine. An American vessel anchored in the bay broke loose and collided with the wooden tower, which was smashed in, giving the water free access to the workings. Wheal (or Huel[1]) Wherry, as the mine was called,

[1] *Huel*, or *wheal*, means *hole*, or pit.

lay abandoned for many years; then a company installed expensive machinery and essayed to carry on Curtis's work. But what that simple miner managed to do—to make money out of his venture—they failed to effect, and the mine soon became derelict again.

Cornwall is not without its *bonanzas*, or rather *carbonas*, as the Cornishmen name large deposits of rich ore. It is supposed that the word *carbona* is connected with the Aramaic word Korban, "a treasury." We know that for a long period in early tin-mining history, Jews held and worked the Cornish mines as securities for money advanced to the then Dukes of Cornwall, and that they left behind the rude furnaces, now known locally as "Jew's houses." We probably have in this word another relic of the Jewish occupation.

The greatest *carbonas* of Cornwall were found in the St. Ives Consols' mines at depths varying from 210 to 642 feet. Here huge bodies of ore were struck, and their removal has left caverns 60 to 70 feet high and as many wide, in their way as remarkable as the Big Bonanza of the Comstock, or the huge copper masses of the Lake Superior district.

Other unusually rich lodes put in an appearance at Wheal Vor, near Helston. At one time the lode seemed to have given out, as all efforts to trace it failed. One old miner thought, however, that the cuts were being driven in the wrong direction, and asked to be allowed to explore on his own account.

His judgment was correct, and soon he had broached a vein 100 feet broad in places, which yielded so much ore that special plant had to be installed for its reduction. History does not say whether old Beaglehole—that was the miner's name—got due credit for his persistence. He certainly deserved well at the hands of the company which he thus saved from insolvency.

Another example of the reward of perseverance can be given in connection with the Old Crinnis mine, near St. Austell. In 1808 this mine was considered to be worked out, but a party of "adventurers," as mining exploiters are called in Cornwall, took it over for better or worse. When they got no return for their money, all the adventurers except one, a Mr. Rowe, retired from the venture. Mr. Rowe stuck to his colours, and tried for ore in another part of the "sett," or property, with the result that at a depth of 60 feet he came upon an extremely rich vein, which in 4½ years left him with £168,000 in his pocket. On learning of his prosperity, the other partners at once claimed a share in the spoil, and when Mr. Rowe refused to let them participate in the good fortune which was entirely due to his private expenditure and enterprise, they went to law with him. It is satisfactory to learn that the verdict was given against them.

We could give a long list of similar turns of Fortune's wheel, which revolves pretty freely in all mining districts. But, as space forbids, we must

pass at once to a short consideration of the working of the mines and treatment of the ore. Generally speaking, the Cornish seams are explored by the system of shafts, drives, cross-cuts and winzes, which has already been described in our chapter on the Rand mines. A typical mine is that of Dolcoath, where the shafts sink to a depth of 2500 feet, and galleries run east and west for half a mile or more, the total of the shafts, galleries, &c., aggregating nearly 30 miles. Half of the excavations have been driven through granite. Dolcoath history records some curious changes. Until a depth of 130 fathoms had been reached, the veins were rich in copper. The next 30 fathoms proved so poor that it looked as if the mine was exhausted. Then tin appeared, and the lode became *increasingly* rich in tin to the 420 fathom level, giving the property a fresh lease of financial life.

Cornishmen employ the "underhand" method of stoping. A gallery is driven above and below the block of ore to be removed, and a perpendicular winze is cut to join the two. The miners then begin hacking at the angles made by the top of the winze and the upper gallery, and remove the ore on both sides in a series of steps, sufficiently steep to allow the material to roll by gravity through the winze into the lower gallery, where it is caught in trucks, to be transported to the shaft. Meanwhile the other winzes have been made parallel to the first, and other gangs of workmen hew

out the intervening "stopes," which may be compared to the panes of a window, the horizontal bars of which would represent the galleries, and the upright bars the winzes. Eventually a great cavity is left where once the ore was, and it becomes necessary to keep the sides from caving-in by stout timbers, and also to leave floors at intervals to catch any falling masses.

The labour of descending, and still more of ascending, the footway of a 2000-foot mine is very exhausting to the miners. Imagine that you have to climb hand over hand up a series of ladders fixed one above the other to a height five times that of St. Paul's Cathedral, and that perhaps this has to be done twice a day, to say nothing of the descent. Then perhaps you will be able to understand why the *man-engine* now generally used in Cornish mines is so welcome to the labourers. The first man-engine was "made in Germany," at one of the Harz Mountain mines, in 1833, as the result of an accident on the ladders then used. It happened that the drainage of this particular mine had just been completed by means of an adit, which threw the pumps out of work. An ingenious miner saw a new use for the idle tackle. Why not attach steps to the one pump rod at intervals, and corresponding steps at equal intervals on the sides of the other rod, with proper hand-holds? Then, by stepping from the one to the other at the end of a stroke, a miner would be transported up or down the distance of the

next stroke, and, by a succession of changes, finally reach the top or bottom, as the case might be. An experimental apparatus, 600 feet high, was rigged up, and it proved so successful that man-engines were soon in use in many Harz mines. Nine years later the idea was imported into England. At the instigation of the Royal Polytechnic Society of Cornwall, the proprietors of the Tresavean mine installed a man-engine. Soon afterwards, 391 of the Tresavean miners put their signatures to a letter thanking the Society for the new apparatus which spared them so much toil and weariness. Other mines followed suit, and now the man-engine is a recognised item of Cornish mine equipment.

The single-rod engine is most commonly used, as being safer, even if slower, than the double. In this case, one set of stages is attached to the sides of the shaft. The stroke is 12 feet, and on a "single-rod" the miner can ascend 1800 feet in half-an-hour, as against one hour consumed in climbing ladders. The cost of working has been reckoned at three half-pence per man per day, and the value of time saved at from sixpence to ninepence per man. So that humaneness has brought its own reward. The ordinary cage-and-rope transport used in the coal mines does not appeal to the Cornishman, who sticks to his engine. The men are so skilful in stepping off and on the moving platforms that fewer accidents are due to the engines than to the ladders formerly used.

Good Cornish ore yields about 6 per cent. of the black oxide of tin, which itself contains 78.6 per cent of metal. When the ore has been brought to "grass," *i.e.*, to the surface, it is sorted out, ground to powder in stamp mills, and well washed to remove earthy matter. The washed ore is then roasted in an inclined iron cylinder revolving over a fire, being poured in at the top. On its way through the cylinder it gives up any sulphur and arsenic that it may contain, as gas. The purified black tin is smelted in reverberatory furnaces, and poled, or stirred, to cause the oxygen to combine with a proportion of anthracite coal that has been added, to form carbonic acid gas, which passes off with the furnace draught. The slag having been skimmed off, the tin is ladled into moulds.

The chief uses for tin are (1) To mix with lead and copper to form alloys for coining, soldering, and other purposes; (2) The manufacture of tin-foil. The metal is so malleable that it can be easily beaten out into sheets $\frac{1}{1000}$-inch thick, which are used for the wrappings of certain kinds of sweets; (3) The "tinning" of sheet iron, to protect it against oxidisation.

We have already remarked that the tin production of Cornwall is diminishing, on account of the increasing expense of raising the ore, and the discovery of rich deposits in other countries. The Malay Peninsula now heads the list of tin-producing districts. The Dutch possessions of Banca and Billiton

yield about 14,000 tons yearly; Australasia, 5000; Bolivia and Cornwall each 5000. It is curious that the United States, rich as they are in almost every conceivable mineral, appear to be *absolutely barren of tin;* a fact which has helped to keep up the price of the metal. Some tin in Black Hills, S.D.

The following table, borrowed from Mr. Robert Hunt's standard work, "British Mining," is a computation of the amounts of tin raised in Cornwall since mining began there:—

In the 500 years before Christ	50,000 tons
" 500 years of Roman occupation	50,000 "
To 1066 A.D.	100,000 "
" 1300	369,800 "
" 1500	42,048 "
" 1600	680,100 "
" 1636	30,000 "
" 1740	235,000 "
" 1834	202,000 "
" 1860	162,000 "
" 1880	195,223 "
Total,	2,116,171 tons

Assuming an average price per ton of £70, we are left with a total value of over one hundred and forty million pounds sterling; a very fine contribution from little Cornwall to the wealth of the world!

CHAPTER XVII

COAL AND COAL MINING

The importance of coal—Its origin—Its formation—The distribution of coal—Some figures—The coalfields of South Wales—Of the Midlands—Of the Northern Counties—Of Scotland—Statistics—France and Belgian deposits—German coalfields—French perseverance—The coalfields of the United States—Some interesting stories about their discovery—Popular prejudice against anthracite coal—Efforts to overcome it—The poker trouble—Growth of the coal industry in the States—The Connellsville coke fields—Indian seams.

HAVING considered the mining of the most important of the precious metals and minerals, we will turn our attention to the subject of coal mining. The subject is, indeed, so vast, that within the compass of a few pages it cannot be more than outlined, and the author of this book has been tempted to leave "black diamonds" out of the list of minerals to be treated, simply on account of the difficulty experienced in picking and choosing among the many things that may and should be said in connection with the world's greatest mineral industry.

Yet from a volume which deals with the more romantic side of mining we cannot omit reference to this great topic. The mere mention of the word coal starts many trains of thought:—the origin itself of coal is so interesting, we might say, uniquely interesting. The natural occurrence of coal is so

widespread; the amounts mined are so colossal; the risks and labour required to raise these masses are so great; the uses of coal are so manifold. Yes! Coal forms the basis upon which the pyramid of mineralogical and most other human industries, and hence human health, wealth, and happiness, ultimately rest. Coal moves thousands of mighty vessels through the seas and oceans. Coal sends a hundred thousand locomotives spinning over the iron ways of the world. Coal smelts the millions of tons of iron ore from which we fashion all our machinery and the countless appurtenances of modern civilisation. Coal makes busy factories hum in towns unnumbered; lights our streets and houses; warms us with its stored sunbeams. We need not extend the list. Let us rather boldly say that hardly a manufactured object meets our eye, hardly a luxury appeals to our senses, that is not due at least indirectly to King Coal.

If we are to avoid confusion we must attack our subject as methodically as the miner attacks the mineral itself, and therefore we will commence at the proper point—

The Origin of Coal.

All of us have read, at one time or another, accounts of the manner in which coal came into being, and what are its constituents. We may therefore dismiss this part of the subject as briefly

as possible. Coal is carbon, *plus* hydrogen, *plus* oxygen, *plus* sulphur, *plus* other impurities. At periods far back in the dim past these constituents took upon themselves the form of gigantic ferns, trees, and mosses which flourished exceedingly in the tropical heat and humid atmosphere of their time. Vast areas of the earth's surface were covered by these dense growths, which in many places were gradually submerged by subsidences of the Earth's crust. Water, salt and fresh, flowing in, very slowly covered them up with deposits of sand and mud, which, in course of time, under the influence of pressure, were converted into sandstone and shale. Myriads of tiny shellfish died in the lagoons overlying the vegetable, sand, and mud strata, and contributed a stratum of limestone. As soon as the surface of these successive strata had reached the water level, vegetable life commenced again; and the operations of Nature's laboratory passed through another cycle. Vegetation, sand, mud, limestone, were superimposed again and again in great blankets ranging in thickness from a few inches to hundreds of feet.

Then came upheavals, distortions, and crackings, as the Earth's crust cooled, and the level strata were bent and twisted into vast hills and valleys. The summits of the hills were washed off by the ceaseless action of water, and carried into the adjacent depressions, leaving the upturned edges of the strata open to the day. The amount of the upheaval

varied greatly in different localities; hence we find the coal deposits of some countries remarkably level, and in others almost as much tilted as silver, gold, or copper veins. On account of the nature of its formation, coal is found in *beds* of comparatively uniform thickness and of great continuity. Where faults are absent, the miner, after once striking a seam, may be able to work steadily ahead for many miles through the solid mineral. Coal mining therefore resembles rather the mining of slate, marble, stone, and other geological deposits, than the raising and working over of large masses of silver, copper, or lead ore, from which only a small percentage of useful material is obtained.

The "coal measures," as the strata are called, which include layers of coal, are upwards of 11,000 feet, or about two miles, thick in places. Sometimes the coal layers are separated by very deep blankets of other matter; sometimes they occur in close proximity, with but the thinnest film of fireclay between them. The fireclay, be it noted, is the soil in which the plants since converted into coal grew, as is proved by the existence in seams of fossil trees with their roots ramifying through the clay.

The Formation of Coal.

Wood, we have already said, contains carbon, oxygen, and hydrogen. During the period when the forests and mosses were rotting they gave off

oxygen and carbon in a combination known as carbonic acid gas, and the mosses gradually changed into a substance called *lignite*, which, according to the pressure to which it has been subjected and the length of time that decomposition has gone on, ranges in colour from a dark brown to a dead black. Under the influence of heat and still greater pressure the hydrogen also passed off with some more of the carbon as carburetted hydrogen, and *bituminous* or true coal was formed. More pressure drove out the gases still further, and *anthracite* coal resulted—almost pure carbon. The next stage produced *graphite*, a substance of immense antiquity; and then came the last stage of all, one in which all foreign elements were driven off, and heat caused crystallisation—and lo! the *diamond*. You will now understand the appropriateness of the term "black diamonds" as applied to coal. It is possible, by-the-bye, to change wood into coal, and coal into diamonds, artificially, though at so great an expense that the De Beers Company need not fear the rivalry of the chemist.

The time occupied by these changes cannot be reckoned in the case of diamonds and graphite; but for anthracite and bituminous coal calculations have been made which may be assumed to be approximately correct. Mr. Maclaren, an expert, reasons that the vegetable matter from which coal is formed was deposited at the rate of one

yard in depth every thousand years. In the South Wales coalfields there is a combined thickness of coal totalling forty yards, overlaid by 12,000 feet of sedimentary matter which was deposited at the average rate of two feet per century. So that apparently this coalfield was 640,000 years "in the making."

The process of coal formation is still going on in our peat bogs, in the great swamps at the estuary of the Mississippi, and in the tropical lagoons of the African coast. Modern research points to the fact that the transformation of bog-moss into peat is largely due to the action of certain bacilli and fungi; and even in coal the microscope has detected what may be called fossil bacteria. Whether present vegetation and present natural conditions are such as would ultimately result in true coal is a question which it is impossible to answer. Mr. Edward Hull, in "The Coalfields of Great Britain," says: "The physical conditions of the coal period stand alone, and we cannot but conclude that they were ordained beforehand for a great and evident purpose." As for the vegetation, we know that the plants which form the bulk of our coal grew to a size vastly surpassing that of their modern descendants, and very possibly the circumstances which promoted their growth also fitted them specially for the change which they afterwards underwent.

From scientific suppositions we will turn to the harder facts of—

THE DISTRIBUTION OF COAL.

It is not, of course, possible to state the exact extent of the world's coalfields, since vast areas of Asia, Africa, Australia, and South America have not yet been prospected. But geologists have calculated that the coal-measures underlie at least half a million square miles of the earth's surface. China and Japan claim between them 200,000 square miles; the United States, 200,000; India, 35,000; Russia, 27,000; Great Britain, 9000; Germany, 3600; France, 1800; Belgium, Spain, and other countries about 25,000. Of late years it has become evident that Rhodesia overlies a huge deposit, which extends indefinitely northwards, and in the future may be found to rival those of North America and China.

As to the quantity which the known coalfields may be expected to yield, this has been reckoned at the enormous total of 600,000,000,000 tons—enough to last for one thousand years at the present rate of consumption. From the deposits of Great Britain over 10,000,000,000 tons have been raised since the year 1600 A.D. During last century the annual output of Great Britain rose from 24,000,000 tons in 1830 to 240,000,000 tons in 1900, which, allowing for the growth of population during the same period, means an increase from one ton per inhabitant to six tons. Even more startling is the augmentation of the United States' supply, which from two and a-half million

A mining surveyor at work in a coal mine. The position of every shaft, gallery, and heading in a mine is determined with great accuracy, and recorded on maps of the mine.

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tons in 1840 has risen to 320,000,000 tons in 1903. To give some idea of the magnitude of the industry on the other side of the Atlantic we may mention that coal forms *one-third* of the total freights moved over the United States' railways.

Germany takes third place among coal-mining nations with 150,000,000 tons annually; France fourth place with 34,000,000 tons; and Belgium fifth with 23,000,000.

There are twenty principal coal-fields in Great Britain. Let us glance at some of these.

First in importance is that of South Wales, extending from Pontypool in Monmouthshire on the east to Kidwelly in Pembrokeshire on the west. It forms an elliptically-shaped basin about fifty miles long from east to west by eighteen miles broad from north to south; covers an area of about 1000 square miles; and has an extreme depth of 11,000 feet. The value of the deposit is greatly enhanced by the fact that nearly half of it is anthracite, which contains 94.10 per cent. of carbon, and which, while burning with a fierce heat, combines so perfectly with oxygen that the products of combustion are practically invisible. Consequently "Welsh steam coal" is of the utmost importance to all war vessels, and large quantities are exported annually to feed the furnaces of the French, German, Russian, Japanese, and other navies. The great coal ports of South Wales are Cardiff, Swansea, and Newport, from which vast

quantities are shipped every month. The mineable coal of the field, *i.e.* that lying within 4000 feet of the surface, has been calculated at 16,000 million tons. Merthyr-Tydvil may be considered the centre of the South Wales coal and iron-smelting industries.

Passing north over the small Forest of Dean coal-field—which has an extent of 34 square miles—we enter the Central coalfields, dotted over an area measuring 100 miles each way. This "bunch" includes the Shrewsbury, North and South Staffordshire, Leicestershire, Warwickshire, North Wales, Lancashire, Yorkshire, and Derbyshire deposits, separated by wide coalless districts.

The South Staffordshire field is notable for containing the thickest single seam in England, the "Ten Yard Seam," as it is called, unbroken by any intermediate layers of fireclay.

The Warwickshire, or Tamworth, collieries give us a large part of our house and steam coal. The North Staffordshire bed, known as the Pottery coal-field, has seams totalling 97 feet in thickness, and is important as being adjacent to valuable beds of iron ore. In Yorkshire and Derbyshire the deposits run north and south for 60 miles, and from 10 to 30 miles east and west. From here is derived the Silkstone, a famous house coal, and Barnsley steam coal. Lancashire contains a bed measuring 52 by 19 miles, with a greatest thickness of workable coal of 100 feet, giving a total bulk of over 16,000 million tons. Durham and Northumberland contain fields measur-

ing 65 miles north and south by 22 miles east and west, its greatest breadth being near the centre, along the course of the Tyne, which is the great highway for exporting coal to the London market. "The central district adjoining Newcastle and Sunderland produces the best class of house coal, known in London as Wallsend, from the pits on the Tyne where it was originally mined, which were close to the eastern termination of the wall built by the Romans to protect the country between the Tyne and the Solway from the incursions of the Picts. These collieries have been long since abandoned, but the name is still given in the London market to the best Durham house coal, and even to much that has been produced in other places, as indicating a coal of superlative excellence. The great merit of Wallsend coal is in its small proportion of ash, which also, being dark coloured, is not so obtrusive on the hearth as the white ash generally characteristic of the Midland coals. The strongly caking property, and the large amount of gas given out in burning, tend to produce a bright and enduring fire. In the district north of the Tyne the produce is principally steam coal, which is known as Hartley coal, being named after one of the principal collieries."[1] The area of this field is 460 square miles, and the estimated quantity of mineable coal is about 7000 million tons.

Passing over the Border we come to the great

[1] *Encyclopædia Britannica*, vol. vi. p. 52.

the attention of these intelligent people, and were remembered by them. They set resolutely to work at once in the environs of Forbach. The ground was bored, pits were sunk, and in spite of the length of time and the patience which are always necessarily required in the prosecution of such undertakings, nothing discouraged the explorers. Capital when spent was followed by the subscription of fresh funds; and if bore-holes and pits afforded no results, others were made. It was also necessary to contend against the water which filled the borings, causing falls in them, or rising in artesian jets. In short, after many years of continuous efforts, the moment of triumph arrived, and man rested victorious in this contest with the ground. At the opening of the Chambers in 1858, the Emperor Napoleon III. announced the discovery of the Moselle coal basin, an extension of the vast and productive basin of Saarbrück." It is sad to have to add that, with the annexation of Alsace-Lorraine by the Germans in 1871, the ownership of the new coalfield passed into German hands.

The Coalfields of the United States.

These also form three great groups: (1) The Alleghany or Appalachian, lying on and to the north-west of the Alleghany Mountains, and including the States of Pennsylvania, Virginia, West Virginia, Maryland, Ohio, Kentucky, Tennessee, Georgia, and Alabama. This field covers about sixty thousand

square miles, an area greater than that of England and Wales. (2) The Illinois and Missouri field, of equal size. Besides trenching on the States already mentioned, these deposits invade Indiana, Iowa, Kentucky, Kansas, and Arkansas. (3) The Michigan field, a deposit of almost circular form, lying in a gigantic limestone bowl, the rim of which shows all round the outcrop of the coal measures. We must add to these groups isolated fields in Colorado, Dakota, Montana, Indian Territory, New Mexico, Washington, Oregon, and California. In short, twenty-nine States are coal-bearing.

Only 460 square miles out of the 200,000 yield anthracite, which is confined to Rhode Island and three fields in Pennsylvania, situated between the Susquehanna and Lehigh Rivers. They are called the Northern, or Wyoming, the Middle, and the Schuylkill, or Southern coalfield. From the Pennsylvania district 365 tons were mined in 1820. This quantity had increased to 50,000,000 tons by the end of the century. The anthracite beds have been subjected to much greater pressure and to more violent upheavals than the bituminous deposits. Some veins lie nearly flat, but others approach the vertical, especially at the edges of a formation. In Rhode Island the anthracite has been so squeezed as to form graphite in places, and so contorted and broken that it cannot be mined profitably.

Anthracite coal in the States is brought up through shafts, now that the surface deposits have been

worked out. Bituminous coal, on the other hand, is got out almost entirely through tunnels driven into the veins at or near the outcrop, since the beds almost without exception lie horizontally and near the surface, so that any depression which has been scooped out by the action of water serves as a convenient point from which to make an entry.

In connection with the discovery of anthracite coal deposits some interesting stories are told, which will remind us of the gold-fields. Before 1790 it had been suspected that coal beds existed along the Lehigh River, but they remained unknown till 1791, when a hunter named Philip Ginther stumbled upon an outcrop quite accidentally. This is his story as related in Mr. Homer Greene's valuable little book, "Coal and the Coal Mines": "He said that at one time the supply of food in his cabin chanced to run out, and he started into the woods with his gun in quest of something which should satisfy the hunger of those who were at home. It was a most unsuccessful hunting expedition. The morning passed, the afternoon went by, night approached, but his game-bag was still empty. He was tired, hungry, and sadly disappointed. A drizzling rain set in as he started homeward again across the Mauch Chunk Mountain. Darkness was rapidly coming on, and despondency filled his mind as he thought of the expectant faces of little ones at home to whom he was returning empty-handed. Making his way slowly through the thick, wet undergrowth, and still looking

about him, if perchance something in the way of game might yet come within the range of his gun, his foot happened to strike a hard substance which rolled away before him. He looked down at it, and then bent over and picked it up, and saw by the deepening twilight that it was black. He was familiar with the traditions of the country concerning the existence of stone coal in this region, and he began to wonder if this indeed was not a specimen of it. He carried the black lump home with him that night, and the next day he set out with it to find Colonel Jacob Weiss at Fort Allan, to whom he exhibited what he had found. Colonel Weiss became deeply interested in the matter, and brought the specimen to Philadelphia, where he submitted it to the inspection of John Nicholson, Michael Hillegas, and Charles Cist. These men, after assuring themselves that it was really anthracite coal, authorised Colonel Weiss to make such a contract with Ginther as would induce him to point out the exact spot where the mineral was found. It happened that the hunter coveted a vacant piece of land in the vicinity, containing a fine water-power and mill-site, and on Colonel Weiss agreeing to obtain a patent for him from the State for the desired lot of land, he very readily gave all the information in his possession concerning the 'stone coal.'"

Another district of the Schuylkill field was also discovered by a hunter in a rather similar way at about the same time. Nicolas Allen had been

hunting all day, and as night came on built a wood-fire to keep him warm while he slept. He was awakened from his slumbers by feeling unpleasantly hot, and there, close by, was the ground itself on fire. That scared him away. But next morning he returned to investigate, and found that he had actually lit his sticks on the outcrop of an anthracite deposit.

This was not the last hunter's find, for in 1826 one John Charles, while digging a ground-hog from its burrow, uncovered a ledge of coal, which afterwards formed the rich property of the Hazleton Coal Company. It is interesting to note, before we conclude the list of happy accidents, that the first coal found in the States, in 1760 (in Virginia), was stumbled upon by a boy while seeking bait for his fishing operations. The reason why sportsmen should have been so successful as unintentional prospectors is easily understood when we remember that in those early days almost every country dweller was perforce a huntsman, trapper, and fisherman, if he wished to keep his larder well supplied.

The Americans were at this time acquainted with the use of bituminous coal, which had been mined in Great Britain long before the Pilgrim Fathers set sail for the New World. But anthracite came as a new thing when discovered. It was unusually hard, and refused to burn in an open grate. True, blacksmiths used it for their forges, where a forced

draught promoted combustion; but in ordinary household fireplaces and smelting-furnaces it appeared to be worthless. People simply refused to buy it, though they would gladly have substituted a fuel for the wood which was generally burnt outside the bituminous coal districts.

Of course, the owners of new anthracite coalfields were grieved at this, and determined to try to convert popular opinion to the true facts—namely, that anthracite will burn in an open fire *if treated in the proper way*. In 1803 six barges of coal were sent down the Lehigh River to Philadelphia from Mauch Chunk. Four were overturned on the way, and the contents of the two which reached their destination safely could not be sold. The public authorities were asked to give it a trial, and did so—in a steam-engine. It refused to ignite. So they spread the rest of it about the public footpaths instead of gravel. The exporters lost heart and closed down their mines.

Ten years later, however, they took courage again and despatched another barge, sending in advance handbills which set forth the correct methods of burning anthracite in stoves, grates, and furnaces. Stoves were erected in prominent places to give the Philadelphians ocular demonstration of the mineral's value. Fires were lit *gratis* in citizens' houses; blacksmiths had *gratis* fuel for their forges. At last the public began to take interest in the exhibitions; though they would persist in *poking* their fires, accord-

ing to an instinct which seems to move any one who comes face to face with burning coal. We will draw upon Mr. Homer Greene for another anecdote. "Among the purchasers of Lehigh coals in 1814 was the firm of White & Hazard, manufacturers of iron wire at the falls of the Schuylkill. They had been told by Mr. Joshua Malin, proprietor of a roller-mill, that he had succeeded in using the new fuel, and as the Virginia coal was very scarce at the time, White and Hazard decided to test the qualities of the anthracite. They purchased a cartload of it, paying a dollar a bushel for it, and took it to their works. Here they tried to build a fire with it in their furnace, giving it what they considered the most skilful manipulation and the most assiduous attention. Their efforts were in vain. The entire cartload was wasted in a futile attempt to make the coals burn. Nothing daunted, they obtained another cartload, and determined to spend the night, if need should be, in the work of building a coal fire. And they did spend the night. But when morning came they were apparently as far from the attainment of their object as ever. They had poked and punched and raked; they had laboured incessantly; but, notwithstanding the most constant manipulation, the coals above the burning wood would not sufficiently ignite. By this time the men were disheartened and disgusted, and slamming the door of the furnace they left the mill in despair and went to breakfast. It happened that one of them had left his jacket in the

furnace-room, and returning for it about half-an-hour later, he discovered that the furnace-door was red-hot. In great surprise he flung the door open and found the interior glowing with intense white heat. The other hands were immediately summoned, and four separate parcels of iron were heated and rolled by the same fire before it required renewing. Seeking for the cause of this unexpected result the men came to the conclusion that it was due to simply letting the fire alone—a theory the correctness of which they afterwards abundantly proved. Thus, by chance, these men hit upon the secret of success in the matter of burning a fire of anthracite coals. That secret is simply to throw the coals loosely on the burning wood and then *let them alone.*"

For the time success seemed assured. But, unfortunately for anthracite coal-owners, the declaration of peace with Great Britain in 1815 opened the way for the importation of foreign soft coals, which ousted the home-grown article, and the mines closed down again. The year 1820 saw the tide turn. Property went up in value by leaps and bounds. Owners leased their lands to companies who paid them a royalty on every ton mined from the strata below, while not interfering with the agricultural operations on the surface. Royalties of twenty-five to thirty-five cents per ton are now quite common. Of late years railway and canal companies have bought up huge tracts of anthracite country at sums ranging to ten million pounds sterling. Owing to the economies

possible when mining can be done on a large scale, with big capital behind it, the price of coal has diminished; and properties which, if owned by individuals, would during times of depression and labour troubles be unable to weather the storm, can, when amalgamated into powerful corporations, hold out through long periods of adversity. The Pennsylvanian coalfields have been the scene of some of the most serious strikes in the world's industrial history, and of deeds which we are glad to be able to include among things that have now gone by. "This sketch of the anthracite coalfields of Pennsylvania," says Mr. John Birkinbine,[1] "could be made to embrace the story of fortunes won and of fortunes lost, of terrible disasters by gas explosion, by fire, or by crushing of supports, relieved by deeds of heroism on the part of those who sought to rescue the injured or to recover the dead. It could include the sanguinary history of the 'Molly Maguires,' when murder was done by order, and of later strikes and riots, by which property and life were sacrificed."

Before leaving the American coalfields, notice should be taken of the Connellsville Coke region, in south-western Pennsylvania. The noun does not imply that coke is there dug out of the ground; merely that here is a deposit of coal particularly fitted for reduction to coke, which is needed in huge quantities to heat the many blast-furnaces of Pittsburg, the steel centre of the world. The seam, nine feet

[1] *Cassier's Magazine*, vol. xxii. p. 520.

thick, has an extent of about 62,000 acres. It is very easily mined, and yields over 12,000,000 tons of coal annually. This is transferred to 23,000 coking ovens, which drive off the volatile constituents and leave the shining residue so prized by Pittsburg ironmasters on account of its wonderful consistency. It is said that, but for the Connellsville coke, the United States would not hold the proud position of first among steel-making nations.

THE COALFIELDS OF INDIA.

Assam is the province most richly gifted with coal, though, owing to its inaccessibility, it has not as yet been extensively mined. The coal is very pure, and is easily worked by tunnels driven into it through the hillsides. In one area, measuring only five miles by one-third of a mile, there is said to lie more than 140,000,000 tons of the mineral. Bengal is dotted over with collieries, which tap the vast deposits that in time to come will be of great value to the industrial expansion of Eastern India, if only sufficient workers can be found. Most of the natives consider mining an occupation unworthy of their caste, or are too lazy to put their hands to work so strenuous. This is particularly unfortunate, since the coal seams are very easily mined, thanks to their broad outcrops, their freedom from dangerous gas, and a good roof: though the coal itself is inferior to that of Assam. When mechanical coal-cutters have been generally

introduced the owners will be less at the mercy of their work-people, who, on the least provocation, indulge in a holiday lasting several days, if they have made sufficient money to meet their simple wants during that period.

Other fields exist in Madras, the Punjab, Burmah, the Central Provinces, and over the border, in Beloochistan.

CHAPTER XVIII

WORK IN THE COAL MINES

The nature of a colliery—Better than it looks—Former cruelty in the mines — The Mines' Commission — "Winning" and "getting"—Prospecting for coal—The diamond drill—Methods of entering a seam—English coal-beds—Shafts—Their construction—Freezing the strata—Depths reached—How coal is "got"—"Long-wall" and "pillar-and-stall" — Ventilation of a mine — Gigantic fans — The mechanical coal-cutter—Electricity in the mine—Transporting and hoisting the coal—Winding devices—Pneumatic hoisting—Breaking, sorting, and washing—What is done with the fine coal and rubbish—The distribution of coal by rail and vessel—The up-to-date collier.

FEW sights are more dreary and depressing than a coal-mining region. The naturally fair face of the earth is scarred by unsightly rubbish heaps of enormous extent, dominated by hideous chimney-stacks, gaunt buildings, and twirling wheels. The earth is blackened, the roads are covered thickly with black mud or black dust; almost every one we meet has a black face as well as a blackened dress. We think of the black depths down below, of the long black list of terrible accidents that occur so frequently in coal-mining annals, of the black records of oppression and slavery that once disgraced the management of these deep pits, and we are tempted to conclude that apparently there is not a single redeeming feature about a colliery.

But stay. Even the darkest picture has its light lines, and if we pry more closely into the lives of our coal-miners, and into the methods by which the mineral is won, we shall find that things are by no means as gloomy as our first impressions may lead us to consider them to be. These miners who pass by us have a free carriage. Some whistle, others are chaffing and laughing, though they have just returned from their "shift" below ground. The labour evidently hasn't knocked the heart out of them. Their toil is severe, but they are well paid, and the hours of work are short. When they feel so disposed they take a holiday—money is plentiful enough for that, and even to allow them to keep bulldogs and a piano, on which instrument some of them are no mean performers. Of course, there come times now and then when cash is short, a thing which happens in all trades and professions.

Then, those engine-houses! Slab and hideous enough outside! But peep inside, and there loom before you magnificent machines performing prodigies of work. Pluck up your courage and peer down the shaft. Ugh! a horror of darkness! Yet far beyond where the light of day penetrates there is a busy town with streets of coal, houses of coal, stables of coal, railways laid on coal; more marvellous machinery; an army of grimy men, each intent on his allotted task, under the guidance of generals, colonels, and captains. There is danger down there, 'tis true. But the men reck little of

that — perhaps too little. It never robs them of a night's sleep. There are animals down there, which were born there, will live there, and will first see daylight when they are past their work; if indeed they come up alive. They don't miss the daylight, however; they have never known what it is.

However, we feel glad that the lot of the brave folk—brave without knowing it—who toil below, is a happier one than it was prior to the investigations of the Coal Mine Commission in 1842. All honour to Lord Ashley (afterwards the Earl of Shaftesbury) for his bold championship of the coal miners! The abuses that the Commission found in existence were appalling; such as to help us to understand why in these latter days the successors of the hapless sufferers that dragged out a miserable existence in the mines sometimes take an unreasonable advantage of the powers of combination. "They [the Commission] found women toiling underground like beasts of burden, surrounded by a loathsome atmosphere of physical suffering and degradation and moral pollution to which savage life scarcely affords a parallel; and children of five and six, and even of four years of age, stunted, diseased, and half starved, compelled to crawl on all fours in the low and narrow passages of the coal pits, dragging by a chain passing from the waist between the legs small carts laden with coal. . . . In many mines, especially in the midland counties, the mines were damp and streaming

with water. No attention was paid there to efficient ventilation or to drainage."[1]

So the poor women and children were soaked through, and half stifled by want of air. It was a common sight to see weak youngsters toiling with trucks through passages only twenty-two inches high, doubling their bodies into shapes which, as they grew older, produced malformation of the limbs. Women had to draw loads nine miles daily. In one instance a girl worked twenty-four hours at a stretch, rested two hours, and then worked twelve hours more! When such callousness to human suffering possessed the mine-owners, it causes little surprise to learn that, through want of proper precautions, accidents were frequent and lamentably disastrous.

When the report of the Commission was produced in Parliament, every member expressed a genuine horror that such things should be permitted in a land where poetry at least declares that nobody is a slave, and an Act was speedily passed prohibiting female labour below ground, and the employment of boys under ten years of age.

To-day everything has been changed. As we shall see, the health and safety of employés is regarded as of primary importance, and human ingenuity has been taxed to render their toil less irksome.

We will now pass at once to the work of "winning" and "getting" coal. "Winning" signifies penetrating to the coal-measures by shafts, tunnels, or slopes:

[1] "The Age we live in."

"getting," the removal of the mineral from the seams. The first operation is one in which the mining engineer has to perform some of his most important offices.

Suppose that a new district is about to be exploited. A company is formed, and an engineer is appointed and sent out to search the country and to decide what is the best plan of operations. Perhaps he may stumble upon an "outcrop" of coal showing on the side of a hill, and be able to calculate the "dip," or angle from the horizontal, at which the seam plunges under the superincumbent strata, and the "strike," or direction in which the seam runs laterally. If no signs of coal are visible at the surface, he must resort to boring with a diamond drill, which has almost entirely replaced the cylindrical steel auger once used for the purpose. Its cutting edge is circular, and studded with amorphous black diamonds, which will pierce many thousand feet of hard rock before they need replacement. An engine is installed over the spot where a test-hole is to be bored, and a hollow rod carrying the drill is attached to an apparatus which gives it a rotatory movement. As soon as this rod has sunk in a certain distance, a second length, with "butt," or flush joints, which offer no obstruction to the descent, is screwed on, and the work proceeds. Water is forced down through the hollow interior of the rods to wash the sludge, or rubbish, to the surface, through the space between the outer face of the rods and the face of

the hole. From time to time the drill is raised, bringing with it a solid core of the substances through which it has eaten its way. An examination of these cores tells the expert "prospector" whether he is nearing coal, and furnishes an exact record of the strata under his feet. At last, perhaps, a black cylinder is extracted—the long wished-for coal. Still the boring goes on, revealing seam after seam of the mineral. The drill is then moved to other spots, and the process is repeated until the engineer has accumulated sufficient information about the lie of the coal to warrant a commencement of actual mining operations. A good diamond drill will sink 60 feet a day, at a cost of about £1000 for as many feet. With greater depths the expense grows, as the labour of raising and turning the drill increases steadily.

If a coal seam comes to the surface at a gentle angle, a "slope" is driven down through the seam; or a tunnel is cut into it from a point below the outcrop, if the latter is discovered on the side of a hill. In the bituminous districts of the United States almost all the mining is done through tunnels, slopes, and drifts, because the coal-beds fortunately lie very horizontally and can be approached at a gentle upward or downward angle. Where possible, the entry is driven up hill, so that mine drainage and the haulage of material to the "mouth" may be assisted by gravity.

In England the coal-beds lie deep and must be

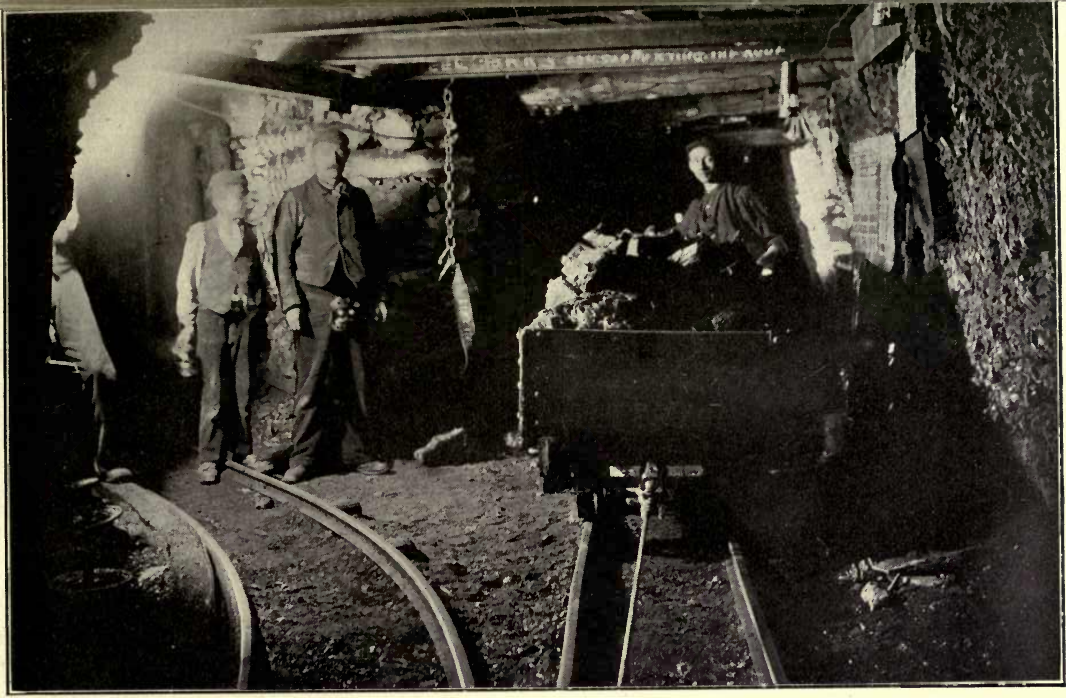
won by shafts. Before sinking a shaft the engineer must decide its most advantageous position, as he wishes to strike the seam as near as possible to the "synclinal axis," or bottom of the bowl, that here too gravity may come to his aid in collecting the water, and rendering haulage easier. The shaft may be round, elliptical, or rectangular. This will depend on circumstances. In soft and yielding strata a round shaft, well lined with brick or iron, is necessary, since that shape offers most resistance to squeezing. But where the overlying measures are solid and hard, a rectangular shaft, at once cheaper to make and more convenient, is preferred. Such a shaft is usually divided into four divisions, the two central ones forming up and down tracks for the cages, and the other two pumping and ventilating shafts. The partition separating off the last must be made quite air-tight by careful boarding and the plugging of all joints. Of late years boring machines have been introduced for sinking. They consist of a central pillar from which radiate arms, each having at its extremity a power-drill to make blasting holes. As soon as the holes have been bored and the charges placed, the machine is raised out of danger, and the charges are fired.

Bricklayers follow the excavators and build a lining round the shaft wherever it shows signs of caving. In some workings the excavations and bricklaying go on simultaneously, the masons being carried by a staging which fits the bore of the shaft

exactly, so that no materials may fall on the heads of the people below. Holes are left in the staging, through which the broken stuff of the blasting operations is removed.

When a water-bearing stratum, such as a quicksand, has to be traversed, the difficulties of sinking are much increased, and it becomes necessary to line the shaft with iron tubing. Sometimes the inflow of water is so great that it can only be kept at bay by air-locks, which act on the same principle as the Greathead Shield for tunnel-driving. In 1883 a most ingenious process of *freezing* the ground round the shaft was introduced by Messrs. A. & H. T. Poetsch, and has been used successfully in France and Belgium. The soft ground is temporarily *solidified* by freezing the water for a few feet all round the scene of operations. To effect this, brine, chilled to a temperature of 5° Fahrenheit, is circulated in vertical pipes closed at the bottom, inserted into bore-holes sunk at regular intervals round the space to be frozen. Each pipe has a central tube of small diameter reaching almost to the bottom. The brine is forced down through this, and returns upwards through the space between the two tubes. When hard ground is reached, an iron lining is lowered, and any interstices between it and the wall of the shaft is filled in with concrete.

Shaft-sinking is expensive work. As much as £100,000 has been spent on a single shaft. The deepest shafts are to be found in Belgium, where



The entrance to a branch working in a coal-mine. To the right is a train-load of coals on its way to the pit bottom. The small chain in the centre has a leather belt attached, and is used for lifting derailed

3790 feet has been exceeded twice. In Lancashire are situated the two finest British examples, 3474 and 3360 feet respectively. English mine-owners are now compelled by law to have at least two shafts to each mine, so that in case of an accident blocking the one, the workers may still have a means of escape.[1] In any case two shafts would be advisable, as rendering proper ventilation more easy ; and in some cases a third shaft is sunk and used only for pumping out the water, which often bears the proportion of three tons to every ton of coal extracted, while occasionally the ratio is four or five times higher.

When at last the shafts have entered the coal seam the "winning" is at an end ; and as soon as machinery for pumping, ventilating, and hoisting is in full working order, the process of "getting" commences.

All round the bottom of the shaft a thick body of coal is left, to avoid any settlement of the roof at this vital point in the workings. From the "pit-eye," as it is called in Scotland, two galleries are driven, parallel to one another, and of large size, the one named the "gangway," or track-way, for haulage, the other, the "air-way," for ventilation. From these headings are driven into the coal, for the removal of the seam.

[1] This legislation resulted from an accident at the Hartley Colliery, where the single shaft was blocked by the fall of the pumping-engine beam, causing the death by starvation of all the poor fellows in the mine.

There are two chief methods of getting coal. One is known as the "long-wall," by which the whole of the coal is removed as the seam is penetrated, the excavated area between the working "face" and the gangway and air-way being filled in with goaf, or rubbish, except for the protected passages, which are needful for the ingress and egress of workers and air, and for the trucking of the coal. The other method is called the "pillar-and-stall," "pillar-and-room," or "pillar-and-bord." In this case only part of the coal is removed, a large proportion being left to support the roof, so that the workings somewhat resemble a large crypt.

The long-wall method requires a good roof and floor, and a seam not exceeding six to seven feet in thickness. When the seam is very thin—not more than three feet thick—only long-wall mining is practicable.

Let us watch the long-wall miner at work. Lying on his side, he attacks the base of the wall with a sharp pick, and undercuts it to a depth of three to five feet. As the excavation proceeds it becomes necessary to insert short, stout props between the floor and the slanting top of the groove, so that the roof may not fall on the worker. As soon as the "holing" of a length is finished, the props are knocked out, and if the coal does not fall naturally, blasting charges are fixed and fired to bring it down. The fallen masses have now to be loaded on to flat trucks—a very arduous task in a space where a

man cannot even stand upright—and shoved to the gangways by "putters."

Long-wall work is very dangerous, since the timber balks, placed in a double row at a short distance from the face, are often unequal to the strain, and crumble like matchwood, allowing the roof to descend on the hapless miners. Its advantages are that it allows room for more men to work in a given area, and is therefore a cheap method: its disadvantages, that it requires more timbering, suffers more by settlements when the mine is idle, and is more difficult to ventilate.

Where coal is over seven feet thick, or where the overhead pressure is very great, the pillar-and-stall system becomes advisable. In some mines the pillars must be left standing, but where possible they are "robbed," or removed, as soon as the limit of the seam has been reached; the miners working from the boundary back to the gangways. Where the coal is very thick it must be mined in terraces, as it were, pillars of extra size being left. The loss from this method is considerable, and the danger from falls of roof much greater than with shallow seams. South Staffordshire, where the seams are sometimes forty feet thick, has an unenviable reputation for crushing accidents.

The problem of ventilation has been solved by a systematic plan of leading the air only through the parts of the mine where work is in progress. In a pillar-and-stall working the headings are driven out

at right angles to the air-way parallel to one another, and as soon as the one heading has progressed a certain distance, an opening is cut to connect it with the next heading. Previous openings are carefully boarded up, and, as a partition has already been built between the points where the headings enter the air-ways, the air is directed up one heading, through the cross opening, and down the next heading, on its way to the "up-cast" shaft—*i.e.*, that through which the foul air is sucked by powerful blowers. When work is done in what may be termed a blind alley, having no communication laterally with another working, circulation is effected by building a wall of thin wood or brattice-cloth down the centre of the heading almost up to the "face."

Air currents are needed for the removal of fire-damp as well as to promote the comfort of the miners; and the greater the amount of gas liberated from the coal the larger must be the quantity of air circulated. In the first half of last century furnace ventilation was generally used. You may imagine an ordinary room to represent the mine, the open fire in the hearth the furnace, the chimney the "up-cast" shaft, and the open door the supply from the "down-cast,"—and there you have the principle of furnace ventilation. The large fire at the bottom of the up-cast expands the air in the shaft, causing it to rise by reason of its lightness. To take its place fresh air rushes in through the furnace, to be itself heated and expelled. Though effective, this method

had its obvious dangers, and several serious mine fires have been traced to it; so that mechanical ventilation is now almost universal. To replace the furnace huge air-pumps were first used, with enormous cylinders, pistons, and valves. They often broke down—a fatal defect, as the air below ground must be kept in *continuous* motion. So they gave way to the centrifugal fan, which is connected with the up-cast in such a way that air cannot reach the fan except from the shaft. The Guibal fan, so largely used, is enclosed in a case, with a central opening at one side through which air is sucked, to be flung by the curved whirling vanes through another opening into the atmosphere. The principle is precisely that of the centrifugal water-pump. Some old Guibal fans had a diameter of forty-five to fifty feet, and were turned directly by steam-engines; but more modern practice uses a much smaller fan turned at a greater speed by steam-engines or by electric motors. The steam turbine, by-the-bye, has proved very effective, on account of its high speed, to work a fan direct. A large fan will pass 1,000,000 cubic feet of air per minute, sucking it through a circuitous course which may run for several miles underground between the down-cast and up-cast. Recognising the full importance of ventilation, mining engineers sometimes sink a special shaft to serve as the down-cast.

We may now return to the "face," and speak of the mechanical devices which are gradually replacing

hand hewing. We have seen that the labour of holing, or under-cutting, long-wall faces, is at once severe and risky. As long ago as 1761 a man named Menzies proposed to work a heavy mechanical pick underground by power transmitted to it by ropes from an engine on the surface. But until the introduction of compressed air into mines it was impossible to operate a practical coal-cutter. We now have four main types of coal-cutters worked by compressed air or electricity—(1) A mechanical pick, which closely imitates the action of a miner, and is particularly useful for the short faces in pillar-and-stall work. (2) A horizontal disc-cutter, much resembling a large, coarse-toothed circular saw. (3) An arm, round the extremity of which passes an endless chain furnished with teeth. (4) A horizontal bar, carrying teeth, which revolves on its axis. Some of these machines, especially those used for long-wall work, are mounted on rails, along which they propel themselves, or are pulled, as the cutting proceeds. For pillar-and-stall operations a pick machine has been invented which makes a vertical cut.

The employment of mechanical cutters is much more extensive in the United States, where 25 per cent. of the bituminous coal is got by their aid, than in Great Britain, where the proportion falls to 2 per cent. But when prejudice permits their wider adoption the economies rendered possible by their use will doubtless help the industry, since the saving per ton ranges from sixpence to a shilling. Un-

fortunately, the miners, like workers in many other trades, fear that mechanical appliances will reduce wages and the need for human muscles, though more probably it would have the opposite effect, to judge by the high pay given in the States, where coal is much cheaper than on this side of the Atlantic, and the quantity produced per man 68 per cent. more.

Electricity is now very popular in coal-mines to light the galleries, move the cars, pump the water, operate cutters, and supply means of communication between the workings and the surface. On the Continent the main winding gear at the pit-head is also sometimes moved by electricity. Compressed air, too, plays a very important part, to turn drills and cutters, pump, hoist, and haul. In the bituminous coalfields of the States both electric and compressed air are employed to bring laden trucks out of the mines. Sometimes the main entrance is there made wide enough to admit of four tracks being laid side by side.

After being broken down, the coal is loaded in trucks and pushed along the branch line leading to the main gangway. Here they are formed into trains for haulage to the shaft bottom (in a deep mine), which is done sometimes by ponies or mules; sometimes by mechanically driven ropes. Where a double track is possible, an endless rope is laid between the rails, passing at one end of the plane round the winding drum, at the other round a fixed pulley. The full cars are hitched to the "up" side of the rope, and so taken to the shaft. The rope

travels continuously in the same direction all the time. When the "tail" rope system is used on a single track the engines must be reversed for the "down" journey.

At the "pit's-eye" a hydraulic lift several storeys high is awaiting the trucks. The lift is lowered, and a truck or two are pushed in. Then it rises a little, till the floor of the second storey is on a level with the rails. On go the second batch of trucks; up it rises another stage; and so on till the loading is finished, and the lift has risen to its full height. Br-r-r! Down comes the cage with empty trucks. These are all pushed off simultaneously into a second lift, which will gradually deposit them while the next load goes up, and the full ones are pushed on board. The shaft is 3000 feet deep; surely the journey to the top will take a considerable time! No, the winding-engines are powerful. Whirr! The signal has been given, and almost before you realise it, the bottom of the cage has disappeared into the upper darkness. By the time the central point of the shaft has been reached, the cage will be flying upwards at the rate of thirty-five miles an hour. Already the cage has finished its journey. It knocks open two flap-doors at the pit's mouth and is brought to rest opposite a second set of lifts, which rob it of the full trucks and puts "empties" aboard. The laden skips are run over a weigh-bridge and tipped into shoots. Then they are restored to the lift for the downward journey.

So the work goes on for hours at a time—empty trucks descending in one division of the shaft while full ones rise in the other. Before the day is over a couple of thousand tons of coal, maybe, have been brought up into the daylight, which last shone on it æons before man first inhabited the earth.

It sounds so simple, this hoisting system, with one cage partly balancing the other. But it is not so simple after all. Don't forget that the rope must be stout and strong, and therefore heavy. Two or three thousand feet of rope weighs a good deal more than the load itself ; so that when one cage is at the bottom all its rope has been paid off the drum, while all the rope of the other has been wound in and so has no counterbalancing effect. The engine, therefore, has less and less to do as the cage rises, for the second rope is exerting an increasing pull ; and soon after the cages have passed one another the descending rope would quite overcome the ascending. To meet this variation of load, tapering drums are often used, the rope winding on to the drum from the small to the large end ; and, of course, unwinding in the reverse order. This helps to keep the balance more even, as the rope exerts less leverage on the drum the farther it is paid out. It must be understood that the cages are not attached to the ends of one rope. Each has its separate rope, sometimes thicker at one end than the other, the larger end being attached to the drum.

Another method of equalising strains is to have

cylindrical drums and a "tail" rope passing from the bottom of one cage round a pulley at the pit's bottom and up to the bottom of the other cage. Thus there is always the same amount of rope between the bottom and top in each cage-way. Whatever shape the drums may have, they are mounted either on a single axis, or are so geared together that they cannot turn independently.

Then there is another difficulty. You can easily see that if a rope is being wound on a drum fixed so that it cannot move laterally, the rope will be at right angles to the drum only at one point. When the rope is very long the "angling," as it is called, becomes troublesome, and to obviate it Mr. W. Morgan mounted engines and drums on a travelling carriage, which traversed a distance laterally equal to the diameter of the rope with every revolution of the drum ; so that the rope always lay on a line drawn through the centre of the "overhead" pulley wheel to the drum, and formed a right angle with the latter.[1]

Every reader has seen, or at least heard of, the pneumatic tube system of despatch. The article to be transmitted is inserted into a carrier, the carrier is placed in an air-lock connected with the tube, and either blown or sucked through it to its destination. Well, the same principle has been tried for coal-raising, and with success, so that it is worthy of

[1] A winding engine of this kind has been recently installed in the Dolcoath mine, Cornwall, to operate a shaft 3000 feet deep.

mention. M. Blanchet fitted the Epinac shaft, near Creusot, in France, with a wrought iron tube, 63 inches in diameter, hammered round upon a special mandrel, and placed on one side of the shaft. The cage, which had nine decks, and carried over $4\frac{1}{2}$ tons of coal, was slung below two air-tight pistons and above a third, and under all was a parachute, which in case of a fall would jam in the tube. Three cages could be loaded and unloaded simultaneously. Their ascent and descent was controlled by valves putting the tube in connection with the exhausting engines or the outer atmosphere. To raise a cage from the bottom the banksman had merely to open a valve and the load was sucked up ; and to lower it he opened another valve which gradually let atmospheric air into the tube, allowing the cage to fall by its own weight. Unfortunately, the shaft did not pierce a coal-bearing stratum, and the pneumatic coal-hoist has therefore not received a trial under full working conditions ; but the device acted so well that, had a seam been struck, it would have done good service. "It is highly probable that we have not seen the last of the pneumatic system of hoisting. Its advantages in connection with deep shafts are numerous. The method can be practised with as great facility in mines of enormous depth as in shallow mines, and the winding-rope, which in a deep mine is a very expensive item, and a constant drain on the resources of the concern, is entirely dispensed with. A large

load can be dealt with at each trip, and the speed of the cages, especially in the descending trip, is almost unlimited." [1]

When the coal reaches the surface it has still to go through several processes before it is ready for sale. Anthracite, and other kinds of coal that come to the surface in very large lumps, must pass through powerful crushers, which reduce the masses to a convenient size. The mineral is then passed along travelling belts, and sorters, standing on either side, pick off the slate, fire-clay, pyrites, and other rubbish that may be present. After that the coal is passed over gratings of decreasing mesh, which sort it out into various sizes. To clean small coal, hand-picking would be too expensive, and washing with water is used instead. The "stuff" is poured into jigging troughs, which keep the contents in constant motion, and cause the heavy impurities to sink to the bottom—whence they are ejected through a valve—and the lighter coal to keep near the top and be carried off by the current flowing through the troughs. The cleaned coal is lifted by bucket elevators into storage bunkers. The fine dust, which formerly was emptied on to the dump heaps along with the rubbish, is now saved, and either converted into coke or into briquettes, according to its nature. Until these new uses for the duff was found the loss was enormous. "It is estimated that from 20 to 25 per cent. of the coal mined was carried to the

[1] *The Engineering Magazine*, January 1904.

dumps. The wasteful methods of treatment are evident in many of the streams which drain the coal basins, for the beds of these consist largely of coal and slate washed by storms from the waste dumps. For a distance of thirty to forty miles below the workings, farmers collect their fuel, and screeners make a good living by digging coal from the beds of creeks, or from bars formed on the banks during freshets, and selling it." [1] This quotation applies to the American anthracite fields.

Even the rubbish is not all wasted, for, in the States at least, a use has been found for it. Where a mine underlies houses there is a danger that settlements may cause the cracking of the walls if the excavations are within a thousand feet of the surface. To prevent this possible damage the plan has recently been adopted of crushing the rubbish, mixing it with water, and discharging the "culm," as it is called, through pipes or bore-holes into the exhausted workings. The water drains off into collecting pits and is pumped to the surface. The solid matter left soon solidifies, and becomes so firm that headings can be driven through it. This method of refilling does away with timbering and the necessity for leaving large pillars of good coal, and also helps to diminish the refuse heaps. It is interesting to note that the idea has been mooted of pumping a mixture of coal dust and water through pipes from the coalfields to distant towns; just as

[1] *Cassier's Magazine.*

natural gas and petroleum are piped so extensively in America. The colliery owners are very anxious to be rid of the banks, and sometimes actually set them alight. In some piles fires have been burning for nearly a century. We may be certain that in the future these huge, unsightly deposits will become valuable; probably as fuel for larger power stations, which will distribute electrical energy through the surrounding country.

From the mines the coal is distributed to the consumers by rail only, or by rail and water. Vast quantities are shipped annually overseas from England and the United States. If you visit Cardiff, Swansea, and Newcastle, in England; Port Richmond, Greenwich Point, Curtis Bay, Newport News, and Buffalo, in the United States, you will see great transporters dumping the mineral by the thousand tons into the holds of grimy-looking vessels. The most sensational methods of handling coal are American, so we will follow them for a page or two. Near the mine is a "tipple," or superstructure, overhanging several railway trucks. The mine trucks are run on to a platform sloping downwards at an acute angle. Their lower ends are opened and their contents fall out on to screens, which sort the coal into various sizes, each of which passes through its own weighing machine, and is shot into the railway cars down below. In this case the sizes are kept separate, and made up into special trains. But if the order comes for "run-of-mine" coal, *i.e.* unsized coal, the

whole is poured without separation into a train of "empties" down below, which is drawn forward under the tipple by the locomotive as each car—which holds upwards of 50 tons—is filled. Then off goes the train, weighing perhaps 2500 tons, to the port, where it arrives without much difficulty, as the grades generally run downhill from the coalfields to the coast. At the port the cars are pushed on to elevated piers, which have openings under the tracks and above the mouths of chutes leading to the hold of the vessel to be loaded. As each car comes over an opening, a trap-door in its bottom is released by pulling a lever, and in five minutes or so the fifty tons have passed into the chute. By discharging several cars simultaneously 2000 tons per hour can be transferred from train to vessel.

Boats specially built for coal transport are now largely used. They are divided by steel bulkheads, running longitudinally and transversely, into large bins; and the cargo is thus prevented from shifting. Where such subdivision of the hold is not made, the collier may, if it meets a gale, alter its trim with disastrous results. Ships of 11,000 tons' capacity have been floated for the coal trade, and in future years even larger units will probably become popular. A great deal of money is saved by the employment of these special ships, since the bin will trim itself, whereas, in a large open hold, the labour of a number of men would be required to make them snug.

CHAPTER XIX

THE MINING OF IRON

The Jermyn Street Museum—Natural distribution of iron—Classes of iron ores—The Edison separating process—Roman mining—The iron mines of Sussex—Consequent destruction of forests—The decline and fall of the Sussex ironmasters—Coal used as fuel for English smelting-furnaces—Sturtevant—Dud Dudley—Abraham Darby—The Bilbao deposits—Aïn Morka—Dannemora—Gellivare—The Cerro de Mercado—The Lake Superior iron ore beds—Methods of mining—The steam-shovel—Remarkable prices—Transporting iron ore to Pittsburg—Other iron countries.

ANY one who is interested in the story of mining should not fail to visit a geological museum, such as is to be found in Jermyn Street, London. This last building is full of objects which, to a casual observer who has just strolled in to "see if there's anything worth seeing," are not peculiarly impressive;—just slabs and pillars of stones; tables made of marble mosaic; cases full of endless specimens; large diagrams of strata, seams, and faults, &c., &c. The first view is rather disappointing. But if we look more closely into things we shall soon find ourselves becoming interested. Here is a diamond drill which, to judge by the worn condition of the diamonds, has done yeoman service. Beside it lie cores of some seams penetrated by it. Above it is mounted a large old-fashioned steel auger, which it has supplanted.

A Steam Shovel, such as is used in the Lake Superior iron-ore opencast mines. The shovel raises five tons at each scoop, and will load a train at the rate of over ten tons a minute.

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The eye is also attracted to some of the lovely copper ores—pyrites of golden colour; blue azurite; purple ore from Cornwall; green ore. The agates and felspars are beautiful to look upon. Antimony ore and asbestos are curious. Many ores would never suggest what they contain; their drab, uninteresting appearance helps us to understand why the Comstock and Leadville miners made such mistakes in the early days. Ah! here is a gilt model of the "Welcome" nugget, the second largest ever discovered; value over £8000. It rouses feelings of envy, as we note the rough, corrugated surface, and try to imagine the sensations experienced by the lucky miner who struck his pick into it nearly fifty years ago.

Close to this model are cases full of iron ore specimens, representing a metal that has been vastly more valuable to mankind than all the gold, silver, and diamonds ever mined put together. In colour, iron ore cannot compare with copper, though the pyrites (or sulphide of iron) is golden, and the Elban ore wears the hues of the peacock. The majority of specimens range from a dirty yellow, through browns and reds, to black. Their shape is somewhat more interesting. Hæmatite, one of the most important varieties of ore, occurs as curious knobs, with smooth, shining surfaces. Spathose iron ore, on the other hand, is made up of curious laminæ, somewhat like butterflies' wings, standing up on edge. Here, again, there is little externally to suggest that the most useful of the metals forms from 35 to 60 per cent.

of these dull-looking compounds. Certainly we cannot see a trace of metal sparkling from the lumps.

Iron is even more widely distributed than coal. We may say at once that scarcely a country could be named in which iron ore deposits are not to be found. Some of the most notable fields will be mentioned presently, after we have briefly enumerated the chemical compounds in which iron occurs.

The only naturally pure iron is that contained in meteorites, which have fallen from the skies, and once formed part of the heavenly bodies. A poetical mind might see in the fall of these errant masses a Divine hint that iron is the most valuable material gift that can be sent to man from above ; and indeed it is remarkable that space should be full of iron lumps whirling about, heated to whiteness whenever they encounter the friction of our atmosphere.

Combined with sulphur, iron appears as ferric disulphide or iron pyrites, which is of little use to the smelter, but valuable as a source of sulphuric acid, or vitriol.

The oxides of iron (*i.e.* substances in which iron is combined with oxygen) are known as: (1) *Magnetite*, also called magnetic iron ore, or loadstone, which contains 72 per cent. of iron, the largest proportion that can combine with oxygen ; (2) *Hæmatite*, brown and red, including limonite, specular ore, lake ore, &c. Hæmatite contains up to 70 per cent. of iron.

Thirdly, we have the carbonates of iron (*i.e.* iron

plus carbon *plus* oxygen), which fall under two main heads: (1) *Spathic iron ore*, otherwise called "sparry ore," siderite, or spathose. This has a crystalline form and is comparatively free from impurities. (2) *Clay ironstone*, found largely in the coal-measures, alternating with coal and limestone. This ore is the poorest in iron, of which it seldom contains more than 40 per cent., but on account of its interstratification with the fuel necessary to smelt it, and the flux (limestone) needed to separate the impurities, it has been till recent years the main foundation of the immense industries of England and Western Pennsylvania; though it has assumed less importance as cheap freights have enabled ironmasters to import richer ores from distant regions to the smelting furnaces of the coalfields, or to transport coal to the districts where the richer ores occur.

Taken as a whole, iron ore falls into four classes:[1]

1. *Rich*, those containing more than 50 per cent. of iron.
2. *Average*, those containing 35 to 50 per cent. of iron.
3. *Poor*, those containing 25 to 35 per cent. of iron.
4. *Useless*, those containing up to 25 per cent. of iron.

The last class is useless, however, only for smelting direct from the ore. Thomas Edison, the "Wizard of the West," has discovered a method of separating the iron from its matrix by electricity. The ore is pulverised in a huge crusher, and the powder falls through a hopper past the poles of a very powerful

[1] British ores average 35 per cent. iron; French, 36; German, 37 Austrian, 40; Spanish, 50; Swedish, up to 66.

electro-magnet, which deflects the particles of metal so that they fall into a special receiver, while the rubbish drops directly into another.

Iron mining, though as compared with some other branches of mining a modern industry, dates back into the unrecorded past. The metal occurs in large pockets near or at the surface, as well as in veins and deep beds, and was therefore easily accessible to workers armed with very simple tools. The Romans mined iron extensively in the Forest of Dean, in South Wales, and in Sussex. At the time of the Norman Conquest the Sussex industry had ceased, since we find no reference to it in Domesday Book, though smelting still continued on the borders of Wales, whence, during the reign of the Saxon Kings, England seems to have derived most of its iron. During the Middle Ages fresh districts were opened up near Warwick and Leeds ; and huge cinder-beds testify to the activity of the workers, who were to a great extent controlled by the abbots of the large monasteries. At this time iron-working was considered an honourable trade ; and even so far back as the regency of St. Dunstan we have evidence that monkish hands wielded the hammer and pincers, since it was at a forge, situated in his *bedroom*, that the Saint had his famous encounter with the devil.

During the fourteenth and fifteenth centuries, England imported most of her iron and steel from Spain and Germany, the business being in the hands of the Merchants of the Steelyard, London. Then

the Sussex furnaces grew busy, fed by the charcoal made from the forests which then covered the Weald. Cannon were cast as early as 1543, and exported in such numbers to Spain that Sir Walter Raleigh said in the House of Commons: "I am sure heretofore one ship of Her Majesty's was able to beat ten Spaniards, but now, by reason of our own ordnance, we are hardly matched one to one," and the exportation was prohibited by law. In Elizabeth's reign the industry reached its climax; though the output was very small as compared with that of other mining districts of to-day. A furnace did not yield more than three to four tons a week. "But to produce the comparatively small quantity of iron turned out by the old works, the consumption of timber was enormous, for the making of every ton of pig-iron required four loads of timber converted into charcoal fuel, and the making of every ton of bar-iron required three additional loads. Thus, notwithstanding the indispensable need of iron, the extension of the manufacture, by threatening the destruction of the timber of the southern counties, came to be regarded in the light of a national calamity. Up to a certain point, the clearing of the Weald of its dense growth of underwood had been an advantage, by affording better opportunities for the operations of agriculture.

"But the 'voragious iron-mills' were proceeding to swallow up everything that would burn, and the old forest growths were rapidly disappearing. An entire wood was soon exhausted, and a long time

was needed before it grew again. At Lamberhurst alone, though the produce was only about five tons of iron a week, the annual consumption of wood was about 200,000 cords! Wood continued to be the only material used for fuel generally,—a strong prejudice existing against the use of sea-coal for domestic purposes.[1] It therefore began to be feared that there would be no available fuel left within practicable reach of the metropolis; and the contingency of having to face the rigorous cold of an English winter without fuel naturally occasioning much alarm, the action of the Government was deemed necessary to remedy the apprehended evil."[2]

In 1581 an Act was passed, which made it penal to convert wood into fuel within fourteen miles of London, to erect new ironworks within twenty-two miles, or to increase the number of Sussex, Surrey, and Kent furnaces beyond certain limits. As a result of this legislation, some Sussex ironmasters removed to South Wales, and the Sussex iron industry declined steadily till 1790, when it ceased altogether. Dr. Smiles says: "The din of the iron hammer was hushed, the glare of the furnace faded, the last blast of the bellows was blown, and the district returned to its original solitude. Some of the furnace-ponds[3]

[1] Because people believed that the fumes were poisonous and injured the human complexion, besides causing certain diseases.

[2] Dr. Smiles, "Industrial Biographies."

[3] These were impounded to supply water power to drive mechanical tilt-hammers.

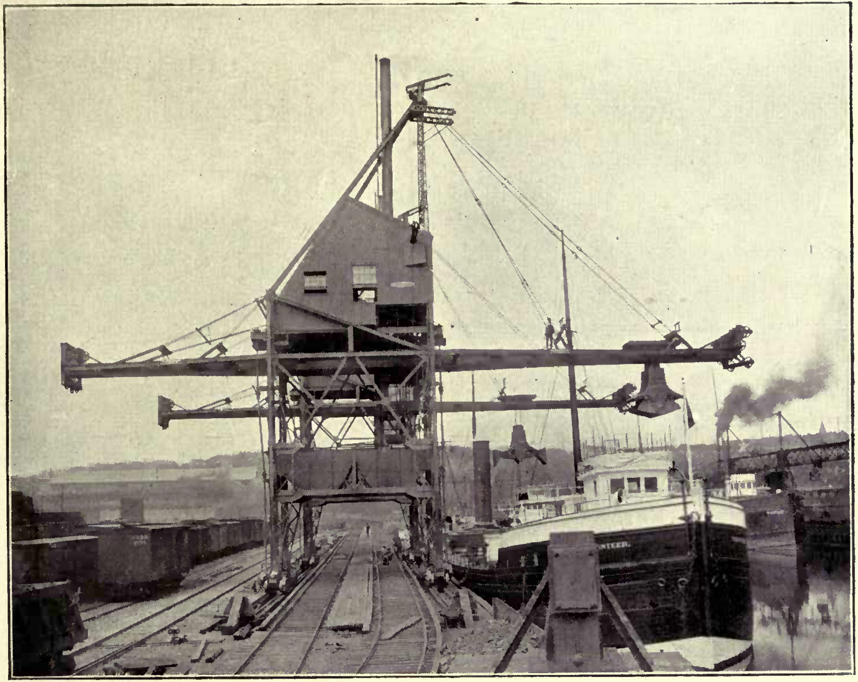
were drained and planted with hops and willows; others formed beautiful lakes in retired pleasure-grounds; while the remainder were used to drive flour mills, as the streams in North Kent, instead of driving fulling-mills, were employed to work paper-mills. All that now remains of the old ironworks are the extensive beds of cinders from which material is occasionally taken to mend the Sussex roads, and the numerous furnace-ponds, hammer-posts, forges, and cinder places, which mark the seats of the ancient manufacture."[1]

Fortunately for England, she contained inexhaustible supplies of a fuel much better suited than wood for smelting. A German, named Simon Sturtevant, took out a patent about the year 1610 for "nealing, melting, and working all kind of metal ores, irons and steeles, with sea-coale, pit-coale, earth-coale, and brush fewell; . . . which will prove to be the best and most profitable business and invention that ever was known or invented in England these many yeares." The concluding words were true enough, for to what dimensions has the iron industry spread not only in England but in other civilised countries, since the employment of coal in the smelting furnaces! The United States alone produced, in 1902, iron-pig worth nearly £60,000,000; and in England, Germany, France, and Sweden also, the industries connected with iron rank second to that of agriculture.

[1] Since these words were written many of the traces referred to have disappeared.

Sturtevant did not do much more than put a large number of words, purposely vague and mystifying, on paper. The real introducer of coal as a smelting agent was undoubtedly Dud Dudley, son of Edward Lord Dudley, of Dudley Castle, in Worcestershire. His patent, "for melting iron ore with coal in furnace, with bellows," dates from 1620. But his invention was born before its time. Never did inventor encounter more discouragement and active persecution than poor Dud, whose private success aroused fears among rival ironmasters that the use of coal would, by increasing output, seriously lower prices. His life was one long struggle against heavy odds, and when he died, at the age of eighty-five years, he had only sown the seeds of the revolution which afterwards overtook smelting methods in Britain.

Abraham Darby was one of the first ironmasters to rely on coal fuel. He made a large fortune out of casting iron pots at Coalbrookdale, South Shropshire, and his successors fairly established his methods. At Merthyr-Tydvil, Mr. Richard Crawshay was in 1812 turning out 10,000 tons of bar-iron yearly, thanks to the proximity of clay ironstone to good coal, and the invention by Henry Cort of the method of squeezing the impurities out of iron bars by passing them through rollers. The discovery of the Blackband Ironstone deposits of the western counties of Scotland, in 1801, led to the establishment of a thriving iron industry there; and from that time



A Brown Transporter for transferring iron-ore from ship to rail, or vice-versâ. A huge clam-shell scoop descends, grips a load, and is run laterally along the suspended railway till over the point at which its load must be dropped.

onward King Coal has been the great partner of King Iron.

Some of the most remarkable iron deposits occur as mountains of ore, which can be quarried out like slate or marble by open-cast workings. Near Bilbao, in the Spanish province of Biscay, are the most wonderful hæmatite mountains in Europe, from which vast quantities of ore are got every year, by a large army of miners. The iron deposits "form huge basins or quarries in the primeval beds of limestone. . . . Lying within a radius of ten or twelve miles from tide water, they have lent themselves readily to the cheapest possible forms of transport. Wire tramways connect the principal mines with wharves of their own, which steamers can lie alongside of and receive cargo as fast as it can be tumbled into them. In the lower parts of Bilbao the riverside is gridironed with iron rails running in from the mines."[1] Ever since the sixteenth century Bilbao has exported iron, the excellence of which was so well established in Elizabeth's reign that rapiers of high quality were known as "Bilboes." Between 1860 and 1901, no fewer than 100,000,000 tons of ore were mined, averaging about 48 per cent. of metal; and the output still reaches 5,000,000 tons annually. The Somorrostro hills contain two huge masses of ore, the Monte Triano and the Monte Matamoros. The former is 3080 yards long, and varies in thickness from a few feet to thirty yards: the latter has a

[1] "Spain of To-Day," W. R. Lawson.

length of $1\frac{1}{4}$ miles, and a maximum width of nearly half a mile. These are worked out by lifts, or terraces, along which run railways. The miners drill holes 15 to 20 feet deep, and put in heavy charges of dynamite, which when exploded detach large masses of ore. The record blast moved 6000 tons. From the workings the ore is carried to the sea coast on elevated ropeways, spanning hill and valley, capable of transporting thousands of tons a day. After the Rio Tinto the iron mines of Biscay form Spain's most valuable mineral asset.

Other remarkable deposits are to be found in Elba, and in Algeria, where, at Aïn Morka, exists a large bed of hæmatite and magnetite 100 feet thick. The Swedish iron mines of Dannemora are world-famous, having been worked for over four hundred years. From these mines comes the purest iron ore known to exist—magnetite yielding 66 per cent. of metal. So very excellent is the ore that the owners limit its production to 50,000 tons per annum, and keep the price at a figure which is possible only from the fact that Dannemora ore has no rival. Originally worked "open-cast," the vein is now attacked through shafts nearly a thousand feet deep, under very modern conditions, which include the use of electric light throughout the workings. With the approaching exhaustion of the Dannemora vein, European smelters are looking about for new Swedish iron-fields, and a rich strike has been made near Gellivare, a small town north of the Arctic Circle, which will

soon become the most northerly important mining centre of Europe. In this district the ore lies in bodies 300 feet thick, said to contain at least 250,000,000 tons. To connect these fields with salt water two railways have been built, the one to Lulea on the Baltic, the other across Norway to the Ofoten Fiord, where the warm waters of the Gulf Stream keep the coast ice-free all the year round. The ore contains over 62 per cent. of metallic iron, so that the value of this iron-mountain can hardly be estimated.

In the future a Mexican deposit, the Cerro de Mercado, will become very valuable. It measures a mile in length, a third of a mile in width, and rises from 400 to 650 feet above the surrounding plain. Humboldt thought that the mountain must be an immense aerolite, though he was undoubtedly mistaken. People of the country, deceived by the lustre of the ore, mistook pieces for more precious metals, hence the belief among them that the Cerro must conceal in its bowels untold stores of gold and silver. That its value is nevertheless enormous cannot be doubted. An expert who reported on the Cerro in 1858 said: "The bulk of the hill is 60,000,000 cubic varas.[1] As the specific weight of the mountain is five times greater than that of water, I found that the quantity of metal amounts to 250,000,000 net tons, which melted will produce at the rate of 50 per cent. the quantity of metallic iron." The quantity

[1] A vara is a Spanish measure equal to 33⅓ inches.

may be overestimated; but many fortunes must lie in that mass. It is curious that, in spite of the enormous quantities of iron which their country contains, the Mexicans until comparatively recently regarded iron as a precious metal—too precious to use in the manufacture of carts and ploughs. A peculiar feature of the Cerro Mercado is the number of ant-heaps covering its surface, each heap composed of myriads of round iron-ore pellets of equal size. The natives use this ready-made small shot for sporting purposes.

When iron ore is found far below the surface, the methods of mining it closely resemble those used in gold-quartz or coal-mining, and therefore need receive no special attention. But the great surface deposits of the Lake Superior Region, which now furnish so large a proportion of the world's iron, are worked on a system which is somewhat different from those in use elsewhere, and deserves mention.

The iron district of Lake Superior extends in a line running across northern Michigan, Wisconsin, and Minnesota, and includes the Marquette, Menominee, Gogebic, Vermilion, and Mesabi ranges of hills. All the mines lie within one hundred miles of the Lake, with which they are connected by rail, as also with Lake Michigan. The varieties of ore found are magnetite and hæmatite. Where the ore occurs as veins, with a very sharp dip, a shaft is sunk through the rock under the vein, and a heading is driven horizontally through the ore as soon as a depth of

about sixty feet below the surface has been reached, and a level is driven along the vein for some eight to ten yards. The ore is then dug out, working upwards, by the overhand stoping method, timber being placed to support the roof. When the miners reach the roof, they extend the original level another length, but leave the ore over this alone, and sometimes for another eight to ten yards. This block they excavate like the first, and then blast away all the timber supports. The roof caves in, filling the chamber, and the central pillar is then worked out and caved. The vein has now had a block thirty yards or so long, sixty feet high, and of its own breadth, excavated. The shaft is sunk another sixty feet, and the process continues, till perhaps a depth of 1000 feet is reached. The chief advantage of this method is, that the amount of rubbish overhead is kept constant at all depths ; the original roof travelling down the vein as the shaft and workings sink.

Where deposits are bowl-shaped, but have a considerable "over-burden," or covering of useless material, the same plan, somewhat modified, is pursued. A vertical shaft, 100 feet deep, is sunk through the containing rock, and levels are driven into the heart of the ore body. From these, timber "rises," or small shafts, are worked upwards to within a few feet of the over-burden, some to act as ladder-ways, the others as shoots down which to pour the ore into skips waiting in the level below. A horizontal slice, seven feet thick, is excavated under the surface

soil, and when a sufficient area has been robbed, the floor is covered with rough planks to make a firm roof for the next slice, and the props are blasted. The surface of the ground sinks in, leaving a visible depression. Slice after slice is thus taken away, and when the main gallery is reached, the shaft is sunk further, another level is driven, more shoots and ladder-ways are worked, and the same series of excavating operations is repeated. Finally, an immense chasm indicates the former position of the ore body. To a being to whom a year seemed but an hour the sinking of the surface would be most mysterious, for not a single worker is in sight.

A third method, called the milling method, utilises the shaft and the gallery, but the "over-burden" is first stripped, and the ore, excavated as in an "open-cast," is poured down minor shafts into the gallery and hoisted through the main shaft. Under certain circumstances this is a more economical way of working than hoisting direct from the surface of the exposed ore body.

Where possible, that is to say, where the ore is sufficiently soft, and the deposits lie near the surface, a cutting is made through the ore, and steam-shovels are used. In the Mesabi district the ore "lies on the slopes of the hills in immense masses with little soil above it. The steam-shovels used are similar to those known in Great Britain as 'steam-navvies,' but are larger and more powerful. Those of the most modern type have three separate pairs of cylinders

and one boiler. They weigh ninety-two tons, and cost about £1900 each. One machine has filled two hundred and thirty-three 25-ton ore waggons, or a total of 5825 tons, in nine hours, but this is a record performance. Five tons of ore can be lifted by the machine each stroke, and five full-weight lifts will fill a waggon. . . . Ten men, exclusive of the train-men, are required to work the machine, which consumes about four cwt. of coals an hour. . . . The Mountain iron mine . . . is half a mile long by 1200 feet broad, and at present 85 feet deep. It is worked in horizontal slices of twenty feet, the vertical range of the steam-shovel. Removal of the surface soil as required is also performed by the machine. . . . A train of ten to twelve 25-ton waggons is run alongside a steam-shovel, and is worked forward by a locomotive as fast as the waggons are filled. It is then drawn out, sorted, and made up into longer trains for transport to the docks (on Lake Superior). These trains usually consist of forty-four waggons, whether full or empty. Whilst one engine is attending a steam-shovel, another is preparing a set of empties to replace those drawn out full. In this way the work is almost continuous."[1] Thanks to this expeditious handling the ore, though pure and rich, is supplied to purchasers at *tenpence per ton* on the waggons!

In the last chapter we noticed the value of Connellsville coke for smelting purposes. Now, Connellsville and the Lake Superior ore deposits are

[1] Messrs. J. and A. P. Head in *Cassier's Magazine.*

far apart, though each forms the complement of the other in the production of high-grade Bessemer steel. To transport ore to Connellsville, or coke to Michigan, would be equally economical, as it takes about one ton of coke to smelt the same weight of ore. But for the rolling-mills and other steel-preparing machinery, steam coal would be needed, and accordingly Pittsburg, in the Pennsylvanian coal-fields, was chosen as the point to which both ore and coke should be brought. The ore is conveyed on large trucks direct from the mine to the lake ports, where it is transferred to special boats in much the same manner as coal, though more expeditiously. A vessel of 5000 tons can be filled in a couple of hours. From Duluth, the chief loading port, the ore-carrier steams to the Sault Ste. Marie Locks between Lakes Superior and Huron. The largest lock is 900 feet long and 60 feet wide, and is said to rank first in the world for size. From Lake Huron the ship passes through the Erie Canal to Erie Lake, and heads for Cleveland, the chief receiving port. Here machinery of the most modern type scoops the ore from the vessel's hold, and dumps it either on huge "stock" piles containing millions of tons against the time when it will be needed for the furnaces, or transfers it directly to 50-ton trucks which will be hauled by mighty locomotives to Pittsburg. At that town the ore is stocked or tipped into buckets which convey it to the tops of the furnaces. Here we will leave it, as the scope of this book does not cover the story of

steel manufacture. We may notice, however, that, thanks to the cheapness of transport and the ease with which both coal and ore are mined, a ton of Bessemer "pig" can be produced at Pittsburg for about thirty-three shillings, or for nearly twenty shillings less than at Middlesborough. No wonder that English ironmasters are feeling the pinch of foreign competition!

The Lake Superior ore beds yield about 15,000,000 tons yearly, and the Mesabi Iron Mountain alone will not be exhausted till some 500,000,000 tons more have been removed. So that this immense iron district, noted also for its copper and coal deposits, will continue to supply Pittsburg for many years to come. But we must not forget that at least as much again is mined in Pennsylvania, Missouri (which has its own iron mountain), New Jersey, Virginia, Colorado, New York, and other States. Furthermore, the United States yield only three-eighths of the world's iron and steel. There are immense iron ore beds in China, Siberia, Russia, Australia, and Africa, which have as yet scarcely been touched. In truth, we cannot imagine a time when the world will be so denuded of iron that the happy possessor of a nail will, like Captain Cook's Otaheitan chief, "receive no small emolument by letting out the use of it to his neighbours for the purpose of boring holes when their own methods failed, or were thought too tedious." Well has this age been styled the Age of Iron.

CHAPTER XX

MARBLE QUARRIES

Carrara—Greek Marbles—The town of Carrara—The quarries—How marble is blasted—Bringing down the hillsides—The *lizzatura*—Road transport—The miners of Carrara—Marble in Britain, Algeria, and India—The marble beds of Vermont—Electricity in harness.

In the north of Tuscany, ranged in a line parallel to the sea-coast, you will see on your map the three towns of Carrara, Massa, and Serravezza. From the environs of these towns comes the famous statuary marble to which Carrara has given its name; marble of a pure white hue, and so free from "foreign matter" that, when broken, it shows a texture much like that of sugar.

The Greeks, a race of famous sculptors, quarried their marble from Mounts Pentelicus and Hymettus, or sent over-seas for it to the Island of Paros. If you wish to make acquaintance with Pentelic marble visit the British Museum, where the Elgin Marbles, removed from the Parthenon at Athens in 1816, may be seen. Beautiful indeed is the smooth limestone in which the Greek artists materialised their ideals.

But the marble of Carrara is almost, if not quite, as perfect as that used by the Athenians. For a thousand years the Tuscan marble hills have re-

sounded with the blows of hammers and picks, and later with the crash of explosions. Augustus boasted that, thanks to Carrara, he had left Rome a city of marble palaces, though he found it one of brick. The old Roman workings still pit the hillsides. Long after they fell into disuse the great Florentine, Michel Angelo, and Antonio Canova, hewed their immortal statuary out of Carraran marble, which to-day still remains without a rival.

Avenza is the port from which the marble is sent all over the world. Blocks of all weights, from forty tons downwards, cover the quay and glisten in the intense Italian sunlight. They have been brought down from the quarries by road and rail.

Carrara itself, a town of about 30,000 inhabitants, is five miles from the coast. The railway leading to it runs over marble ballast, and through tunnels driven through solid marble. Every siding is full of marble-laden trucks. The town appears to be one vast workshop, where everybody, from small children to old grandfathers, lives by his chisel and mallet. In the lower rooms of the houses all kinds of carving are in progress. Here mantelshelves are being smoothed and polished; there tombstones. The sculptor of artistic statuary also has his studio here. He comes to the marble. It is cheaper than to have the marble sent to him. The streets remind one of Juvenal's account of Rome: they are filled with wains, creaking beneath their white loads, and hauled by long strings of horned oxen, whose move-

ments are spurred by drivers perched on the yokes. Like Johannesburg, Carrara is a city of dust, but here the dust is snowy, and comes, not from piles of rock-rubbish, but from the workshops.

The town is indeed interesting; but the visitor would be disappointed if he had to leave the neighbourhood without first visiting the quarries where the brown quarrymen blast and hack and cut the marble from the living rock. As the hills are practically solid marble, there is no need to tunnel for it. Beginning at the foot of a slope, the workmen cut into its sides, until a gigantic semicircle has eaten far back into the mountain. Large masses are detached by dynamite, which is placed in very carefully drilled holes, and in such quantities as to separate, without splitting, the marble. "The first visible sign of the operation is the sight of masses tumbling down the mountain-side, thirty and fifty-ton blocks looking like mere pebbles. The distances are enormous, but the animated black specks, which one knows to be men, are clearly silhouetted against the surrounding whiteness. Something like a black ant suddenly makes its appearance and blows a sonorous blast on a horn; other horns, numbers of them, take up the warning note, the sound gradually dying away in the distance. Then more ants are visible, swarming to the shelter of a bomb-proof or casemate. After the last horn has ceased sounding not a soul is to be seen; then comes the boom, the rattle, and the falling pebbles, and presently the

ants swarm out again, apparently from all sides, and proceed to drill more holes and put in fresh blasts. The men must love the sound of that horn, for it means a ten minutes' loaf for them."[1]

The easiest part of the work has now been done. It doesn't take long to drill a few holes and insert charges. But the removal of the blocks to the sea-coast is a tedious, somewhat dangerous, and very laborious business: and in some quarries the job is done by contracts made with the hauliers, locally called *lizzatura* and *caravana*. The former only undertake the lowering of marble, after it has been roughly squared, from the spot where it comes to rest after blasting to the nearest waggon-track, or to the railway.

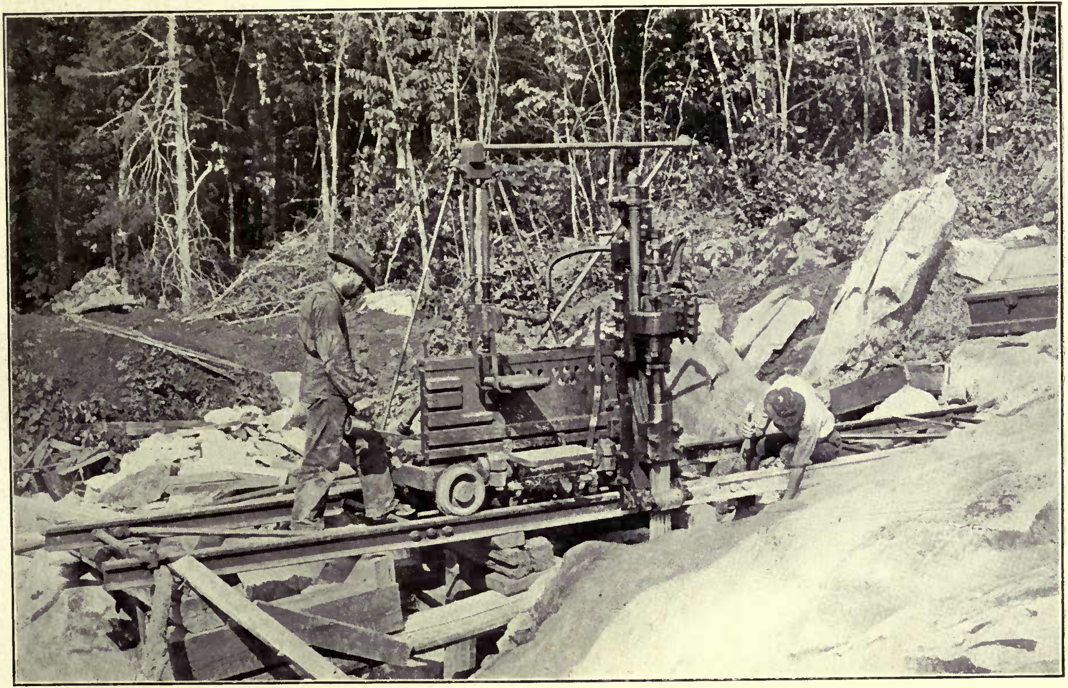
Certain paths have been selected down the marble-covered slopes, over which the blocks will slide most easily by force of gravitation. The difficulty is not so much to pass the material down as to prevent its going too fast, and causing damage to itself and to anything it may encounter. Watch these *lizzatura* at work. They have produced screw-jacks and levers, with which they slowly raise a block on to a solid sleigh of hard beechwood. Ropes, or rather cables, for they measure from three to five inches in diameter, are then passed round the block. Now, if you use your eyes well, you will see, ranged at intervals down the slope, stout posts driven into the loose stones and rubbish. By means of the ropes—

[1] E. St. John Hart in *Pearson's Magazine*.

law enforces the use of three—and the posts the stone is gradually allowed to slide down the track. As soon as it begins to move a man places a second skid in its path, and when it has passed over the first this is picked up by a follower, who hands it to a man perched on the stone, to be soaped and handed forward again. The same three or four skids are thus used in rotation over and over again. The men who lay the skids naturally run the greatest risks, and occasionally the ropes break and one is killed.

At last the descent is accomplished. It now only remains to raise the block on to waggon or truck. This process includes a great deal of shouting and yelling, by which the workers apparently try to drown the sensations of severe muscular exertion. The screw-jacks once more come into action, and levers are requisitioned. The men tug and strain, working with the harmony born of much practice, and the moment soon comes when they can fling down their tools and make a rush for the nearest wine-shop.

The *caravana* now get their innings, if road transport is used. The waggons have very powerful brakes, wherewith to control the descent on the down grades. Water has worn the road until it suggests the bed of a mountain torrent rather than a track for wheels, and the "going" is far from easy. Remember that some of these blocks weigh as much as four traction-engines; and you know how one of these machines will impress the surface of a well-made road.



An Ingersoll Sergeant Channelling Machine at work on a bed of marble. The cutter is seen entering the marble

"The people engaged in this employment," writes Mr. Hart, "which is practically hereditary, are a fine, sturdy, hard-working race of mountaineers. They are true Highlanders, and not in the least like the Italians of the towns. Many of them have to climb three, four, and even six miles before reaching the scene of their labours. Their wages or earnings range from fifteen shillings to one pound per week, and they generally work in gangs, each gang being under the control of a headman, who is more or less one of themselves, with the difference that he has saved or made money; and it is with him that the owners usually contract for the quarrying and transport of the marble."

The 400 quarries of the Carrara neighbourhood employ nearly 7000 men, and produce 185,000 tons of marble annually. At Avenza the marble is worth about £3 per ton.

Though the British Isles afford no single centre of marble quarrying operations to compare with Carrara, they can claim some fine deposits. South Devon yields marbles of rich tints and handsome markings. Black marble comes from Galway, Kilkenny, and Derbyshire. Near Swanage the famous Purbeck—of a mottled, greenish grey—is quarried.

In Algeria are beds of the beautiful so-called onyx marble, very transparent, with delicate yellow and brown tints. The glorious Taj Mahal, at Agra, in India, is built of marble from the Makrana quarries of Rajputana.

The United States marble industry ranks second to that of Italy. In South Vermont, round the town of Proctor, are huge beds of the precious limestone, through which diamond drills have been sunk to a depth of over 200 feet without entering any other substance. The Sheldon quarry, the deepest marble pit in the world, has its bottom 250 feet below the surface, yet there are at present no signs of exhaustion. Much of the marble is got by "open-cast" working, but in places where the over-burden is heavy great caves have been hollowed out in the hillsides, so large that several thousand people could promenade in them comfortably. In Vermont explosives are not much used, their place being taken by electrically- or steam-driven machinery, which cuts long and deep channels through the marble, dividing it into great blocks, which are separated from their beds by wedges. A stream, the Otter Creek, has been harnessed to turbines of 3000 horse-power for the generation of electric current, and to saw-mills in which the blocks are cut and ground. The electricity generated is applied to all kinds of machinery, from the giant gantry cranes, which pile thirty-ton lumps as easily as if they were bricks, and the monster lathes turning the surface of pillars twenty-five feet long, to small mechanical chippers, wherewith the monumental mason traces intricate designs on headstones. It also helps to convey sand for the sawing of the blocks into slabs, on a cable-way which crosses a mountain from

the sand beds two and a-half miles distant. The Otter Creek is thus responsible, in one way, for making Proctor the centre of the States marble industry. One company alone quarries from 60,000 to 70,000 tons annually.

CHAPTER XXI

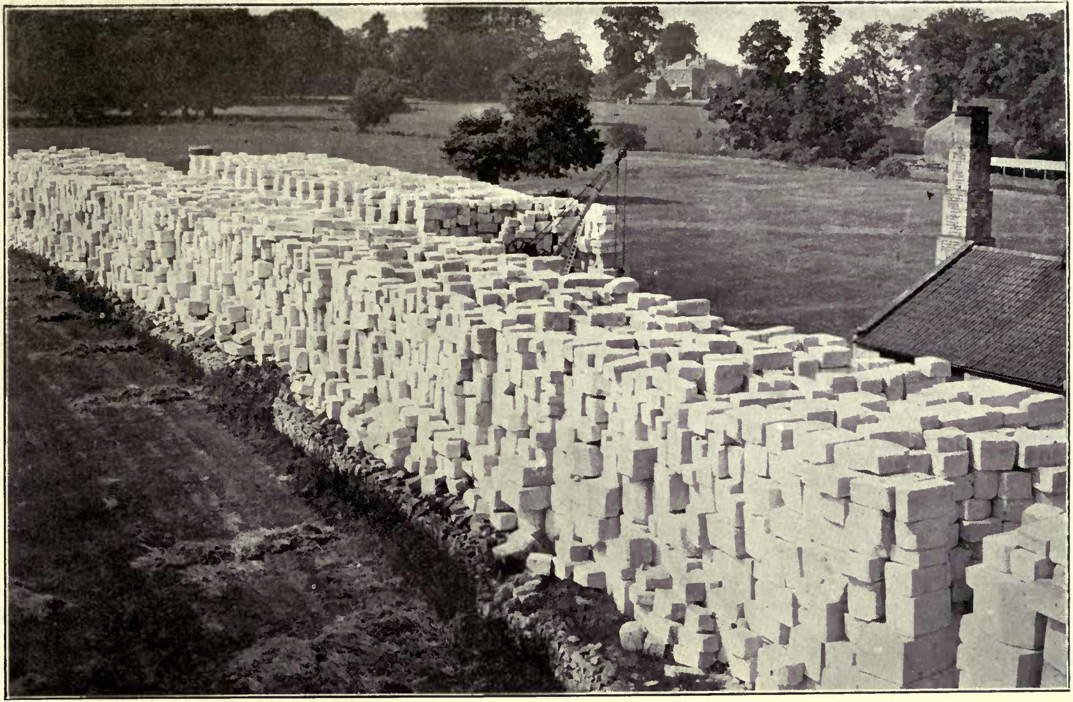
STONE AND GRANITE QUARRIES

Bath stone—Early users of it—A stone for country mansions—Ralph Allen and John Wood—The quarries—Their extent—How stone is got—The quarry horse—Its cleverness—Portland stone—Convict *v.* free labour—A curious custom—Granite—The Aberdeen quarries—The hardness of granite—A record blast—Sawing and turning granite.

AT Corsham and Box Stations, on the Great Western Railway, situated respectively at the eastern and western ends of the famous tunnel excavated by Brunel, you will see trucks laden with large blocks of white stone standing in the sidings, and also piles of the same material in the station yards.

This stone is that named after the neighbouring city of Bath, which is almost entirely built of it. The characteristics which make it specially valuable for building purposes are its freedom from "grain," its ability to resist the effects of long exposure to the air, and the ease with which it can be cut and carved. The hills surrounding Bath are largely composed of this oolite, or freestone, which is quarried from them, and despatched in huge quantities to all parts of Great Britain, and even to Canada, Africa, and India.

The mining of Bath stone is no new industry. The Romans during their occupation of Britain



A huge stack of Bath Stone at Corsham, Wiltshire, piled ready for removal to all parts

soon discovered the worth of the oolite, and used it for the fine and interesting buildings which still encircle the hot mineral springs which draw so many invalids to Bath. The excellence of their preservation, though they have existed now for more than two thousand years, testifies to the wisdom of the Romans in selecting their material.

Bath Abbey was built of the same stone by the Saxons, who also used it for the fine abbey at Malmesbury. This stone apparently came from the Box quarries, which, so tradition tells us, owed their discovery to St. Aldhelm, the first abbot of Malmesbury, who, as he rode over the hill, threw down his glove and bade his men dig there, as they would find great treasure, meaning the quarry. The same saint also erected the Saxon church at Bradford-on-Avon, which, though very small, is one of the finest specimens of Saxon architecture in the country.

Centuries later, famous country residences were built of stone brought from Box—Longleat, the residence of the Marquis of Bath ; Lacock Abbey, near Chippenham ; Bowood, the seat of the Marquis of Lansdowne ; Corsham Court, the home of Lord Methuen ; and more modern mansions, such as Westonburt and Witley Court.

The two men who may be considered to be the founders of the great industry that now engages so many of the folk living near the Box Tunnel, were Ralph Allen and John Wood. Allen came to Bath in 1715, and four years later established a system

of bye and cross-posts, which was the forerunner of our present postal service. Seeing the necessity for a good supply of building stone in a neighbourhood which had become the fashionable resort of Londoners, Allen re-opened the quarries on Coombe Down, and also those on Hampton Down. He was ably seconded by Wood, an architect of high repute, whose genius is stamped on many of the streets, squares, crescents, &c., which still render Bath remarkable, and at the time when they were built attracted people from the Metropolis. It was chiefly due to Wood's efforts that Beau Nash succeeded in making the city a pleasure as well as a health resort. In 1737 Allen built the stately mansion at Prior Park. The foundations alone consumed 8000 tons of Bath stone, the superstructure 30,000 tons. Even to the sash-bars of the basement windows, every external detail was made of the stone. The pile is more than a quarter of a mile long from wing to wing. Pope, the poet, wrote of it as extremely comfortable; and a contemporary, as "A noble seat which sees all Bath, and which was built probably for all Bath to see." In short, Allen made a huge fortune out of his post and quarries, and Prior Park was the outward visible sign of it.

Since Allen's time the industry has increased enormously, on account of the facilities of transport which the railway affords. It is an interesting fact that the driving of the Box Tunnel, which was at the time regarded as an act of folly, led to the

discovery of vast stone deposits, which have been mined, until now the hills are honey-combed with over sixty miles of workings.

Speaking generally, Bath stone is got from underground chambers, adits being driven into the deposits. Oolite is found at depths ranging from 100 to 120 feet below the ground surface, sandwiched in between strata of comparatively useless stone. The seams range from 20 to 30 feet in thickness. The mines—for such they should be termed rather than quarries—are of enormous extent; indeed, there are no similar works in Great Britain which penetrate so many miles underground, and none in which men enjoy such immunity from bad air and falls. The Box quarries run under the Down for miles, and the quarrymen residing in that neighbourhood prefer, when the weather is bad, to walk to their work through them rather than over the surface, though they have to light their steps with a small hand-lamp. Year after year fresh chambers are opened, their position being carefully shown on a large map kept in the manager's office. A glance at this map will make you wonder how anybody can ever find his way through the maze. Stories are told of people who have been driven by curiosity to explore abandoned workings, with the result that they have lost their way, and either starved to death or been reduced to extremities before being found by search parties; and, indeed, such tales can be easily believed. So far-reaching are the quarries

that a visitor can enter them at Box, and travel straight ahead till he emerges at Corsham, miles away, having actually passed over Brunel's tunnel.

For a description of the working methods practised in the quarries, we are indebted to Mr. T. Sturge Cotterell, the manager of the Bath Stone Firms, Ltd. The system generally used is an inversion of that used in coal-mines. The coal-miner undercuts the face, so that a mass may fall away and break. But building stone so worked would make a valueless rubbish heap. The freestone miner, therefore, commences operations above the stone. With the aid of adze-shaped picks, to which longer handles are fitted as the work proceeds, he cuts a deep horizontal groove 8 or 9 inches high, and extending 6 to 7 feet back into the rock. It is evident that the removal of this thin layer of material immediately under the ceiling will disclose any weakness in the roof as effectively as if the stone had been excavated from ceiling to floor, and any tendency to settle is at once detected and guarded against. Assuming that the "holing" has not revealed any signs of danger, the miners now get out their one-handled saws, insert them at each end of the groove, and cut through the stone vertically and at right angles to the face, until the first natural horizontal parting is reached. The block has now been detached on top, at each end, and below. At the back it still is solid with the rock. Levers are driven into the bed, or parting, at the bottom of the block,

and weighted and shaken till it breaks off at the back. It is then drawn down by crane power, and the broken end and the bed are dressed with an axe, so as to make the block shapely before loading it on a trolley for removal from the chamber. As soon as one block has been got out, the workmen can attack others at the back as well with their saws, so that all farther breaking off is rendered unnecessary. At each face, or heading, of work a 10-ton crane is erected in such a position as to command the whole. These cranes are now constructed telescopically, so as to accommodate themselves to slight variations in the headings, arising from differences in the depths of the valuable beds, and the expense otherwise attendant on frequent alteration of the crane is thus avoided. After a block of freestone has been loosened *in situ*, a Lewis bolt is let into its face, and it is drawn out horizontally by the crane. The removal of the first stratum leaves sufficient space for the workmen to "hole out" another groove in the new face, and also to make more vertical cuts down the first face, so that the face soon has a terraced appearance.

Hand-holing has, to a certain extent, been replaced here, as in coal-mines, by a mechanical apparatus hailing from America, and worked with compressed air. The star-like head of the picker, striking the face many times a minute, soon pulverizes the stone, which is scraped out with a special scoop.

Of course, large pillars of stone are left to support

the roof. The toughest varieties of stone will withstand a crushing pressure of about 200 tons to the square foot, or $1\frac{1}{3}$ tons to the square inch. In the Monks Park and Corsham workings the stalls, or chambers, can be driven to a width of 25 to 30 feet without danger of caving; but in the Box Ground quarry, the largest safe span is limited to 20 feet.

The stone blocks, after being detached, are measured and marked. As a rule they do not exceed 7 tons, though for special purposes 9 to 10 tons is attained. Horses are used to transport the blocks through the tunnels, or to the bottom of shafts, where a powerful engine hauls them to the surface. These horses are fine animals, as regards both their strength and intelligence. The miners are proud of their dumb helpers, and will give you examples of their "knowingness." A typical yarn is spun of an old "leader," whose ear told it that a truck approaching from behind had evidently broken loose, and that to stay on the track would mean certain death. The sagacious animal, therefore, jumped into a truck near by, though it must have judged its position by instinct, as the place was pitch dark, and thus saved its life.

The stones are stacked in large heaps on the Downs from March till September, have the natural moisture dried out of them, and become "seasoned" to weather changes. From Corsham and Box stations the blocks are sent by rail to all parts of the kingdom, or to seaports, where they are put aboard ship for the Colonies.

An Oolitic Stone Quarry, Indiana, U.S.A. The deposit has been cut into terraces by steam channeling machines, which make deep vertical grooves.

Another famous oolitic stone closely resembling the Bath, is that of the Portland peninsula in South Dorsetshire. About half of the peninsula is in the hands of the Bath Stone firms, who work over 100 quarries. The Government finds employment for convict labour in other parts of the "island"; but most of the actual stone-getting is done by the free worker. Nature has behaved kindly in Portland, for the stone lies open to the sky, and is split by fissures which greatly aid its removal—conducted on the system already described, except that no "holing" is required. In 1904 no fewer than 90,000 tons of Portland stone were sold by the Bath Stone firms, a considerable portion of which went to build the new War Office in Whitehall. A member of Parliament asked in the "House" why the stone necessary for these Government contracts was not obtained by convict labour from Government property. The reply was that, if the nation relied on convict labour, the new War Office would not be ready for occupation for a thousand years. "One glance at the convict quarryman," says the *Stone Trades Journal*, "is sufficient to prove their inefficiency as workmen, though their labour is anything but light, and industry is everywhere; but the lack of scientific arrangement, so absolutely essential in the management of a quarry, and the scarcity of necessary plant—only one crane is visible from the outer world—render a result totally inadequate to the amount of energy expended, only small blocks

being won, which are used in the ubiquitous Admiralty works. The Portlander is born a quarryman, and grows a clear-eyed, clear-skinned Hercules. The heavy manual exertion required makes them deliberate in their movements, and from the few accidents that occur in their dangerous occupation, marks them as careful and intelligent workmen.

"A curious custom renders these Portlanders vastly interested in their work. From time immemorial, in the event of a man dying intestate, his real property was divided equally between his sons. In the event of land being concerned, it was either literally walled off into the requisite number of strips, or an undivided ownership was acquired. As the stone industry grew, the value of their land increased with leaps and bounds, with the result that to-day there are many men working in the quarries and earning, say, £2 a week, who are in receipt of royalties amounting from £50 to £100 per annum, derived from the stone won from their own land."

In the stone yards near the quarries, circular saws, having diamond tips to their teeth, cut up blocks as if they were wood, and lathes and planing-machines are always busy. Every week 2000 cubic feet of finished work, and 1000 cubic feet of sawn stone, leave the yards. So great has been the demand for Portland stone recently, that the company has over 1,000,000 feet of stone in store for any emergency, and constantly adds to it. There is said to be enough stone on the "island" to withstand the drain

for centuries. In fact, the promontory is just one big mass of useful material.

Another stone to which reference should be made in this chapter is granite; and the mention of granite takes us at once to Aberdeen, where over 9000 people find employment in quarrying and shaping this stubborn rock. The Pharaohs used granite freely for their statues and temples, but on account of its extreme hardness it has not been what may be called a popular stone until quite recently, when the introduction of mechanical tools and improved processes has rendered its working much more easy than it was formerly.

What Allen and Wood were to Bath stone, John Fyfe and Alexander Macdonald have been to granite. Of these the former greatly advanced quarrying methods, the latter the process of dividing and dressing the stone. The quarries in the Aberdeen district are numerous, and also those of Peterhead, whence comes the beautiful red granite often seen in company with Aberdeen grey. The workings are "open-cast," and somewhat resemble the Carrara quarries. Here no hand-sawing can be done. Gunpowder must be used to detach lumps; the holes for the charges being made by hand-drilling or—and this is now becoming the fashion—by rock-drills, which can bore a hole eight feet deep in an hour or so. The number of holes required depends on the size and the position of the block. Perhaps two or three suffice, or a dozen may be wanted. But what-

ever the number, the blasting must be done carefully so as not to split the granite into several pieces. Sometimes two blasts are employed, the first only partially detaching the granite, the second finishing the separation.

Of course, the block leaves the "face" in a rough condition, and must be trimmed up. This is done not with an axe or a chisel, but by splitting along the grain with wedges. Over the quarry runs a stout steel cable, securely anchored at each end; and along it travels a carrier, driven by a steam-engine hauling on an endless rope. A "fall" rope, passing over a wheel in the carrier, is lowered into the quarry and made fast to the block, which has already been moved to a position below the cable by a powerful crane. At the signal the engineman starts his machinery, and the granite cube, weighing perhaps five or six tons, is swung aloft, one, two, three hundred feet, until it reaches the carrier, and is then drawn horizontally to the "bank," where the material is sorted out and committed to railway truck or waggon. All sizes of stuff, from the largest block to mere chips, have their use. "Waste not, want not," is the motto which the quarry-master lives up to.

About ten miles WNW. of Aberdeen, on the river Don, is Kemnay, where a record blast was made some years ago. No paltry half-dozen tons were the object of attack, but a regular mountain. To insert the charges effectively it was necessary to drive a tunnel right through the mass, with branches

to points on the intended line of cleavage. Two and a-half tons of powder were placed in the berths, and joined up with an electric circuit. Everybody was ordered to a distance, and then the man in charge pressed a button. Bang! The earth shook. Before the rumbling had died away 70,000 tons of granite had parted company with the mother rock, and were ready for the sawyers and blasters. This huge mass, when reduced to manageable blocks, furnished loads for 9000 trucks!

As compared with the handling of Bath and other soft stones, the treatment of granite is slow throughout. It is slow work blasting it; slow work sawing or splitting it; slow work carving it; slow work polishing it. As for the sawing, a toothed saw would lose its edge in a moment when brought into contact with granite. But if you use a band of steel having a smooth edge, and keep between it and the granite a mixture of water and iron-sand, the blade will gradually sink down into the block—a few inches in the hour—though it seldom, if ever, comes into actual contact with the stone in the bottom of the cut. The chipping of designs is now done largely with pneumatic chisels; and the rounding of long pillars is performed by lathes. The cutting tool does not *shave* off the surface as the pillar revolves, but *chips* it.

We might describe the polishing of granite, but as this scarcely falls under the category of mining, we must pass to our next subject—stones of a much more valuable nature.

CHAPTER XXII

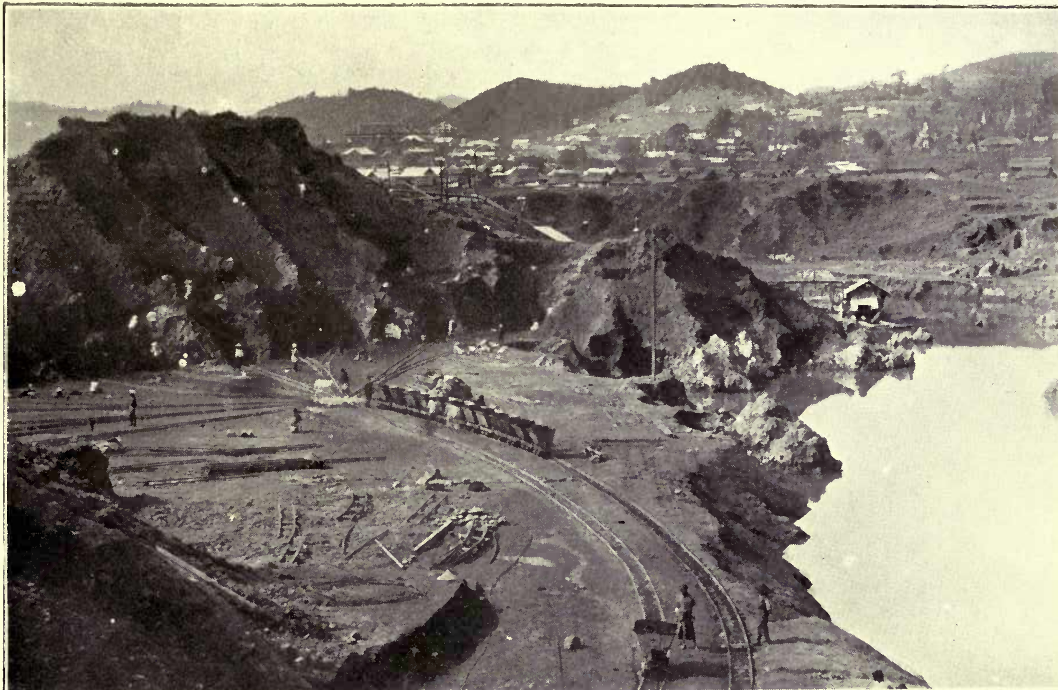
THE BURMA RUBY MINES

The value of the Oriental ruby—Its composition—And qualities—The Burma ruby fields—A curious law—Annexation by Great Britain—Leased by the Burma Ruby Mines Company—Their engineer's difficulties—Attacks on the *byon*—Spiders Hill—Tagoungnandaing—A fine stone found—Operations in Mogok Valley—Methods of working—Testing the stones—Native miners—The ruby shops of Mogok—Electric power—Troubles from inundations.

WE have already mentioned the fact that the Oriental ruby is more valuable than the diamond, weight for weight. Mr. Edwin Streeter, an expert in such matters, affirms that a ruby weighing five carats is worth ten times more than a five-carat diamond; and that the proportion grows rapidly in favour of the ruby with an increase of weight. Casting about for actual figures, we find that an eleven-carat ruby, sold in London a few years ago, fetched £7000; whereas a diamond of eleven carats would not, according to ordinary reckonings, be worth more than £1000 at the utmost.[1]

The Oriental ruby is a variety of the substance called *corundum*, which is chemically known as an oxide of aluminium. It is interesting to notice that,

[1] The value of a cut diamond is roughly reckoned by assuming one carat to be worth £8, and multiplying this by the square of the number of carats that the gem weighs. Thus, an eleven carat diamond = £8 × 11 × 11 = £968.



The upper "lift," or terrace, of the Shwebontha Ruby Mine, Mogok, Burma. The top of a hill has been almost entirely dug away and passed through the washers, which separate the earth from the heavier gravel and precious stones. The bottom "lift" (on the right) has been filled with water by the torrential rains of the district. This mine supplies a large proportion of the world's annual ruby output.

while the oxide is so rare and valuable, silicate of aluminium forms the basis of all clays, and that the sulphate is familiar as alum.

When tinged with blue, corundum is named sapphire; with yellow, Oriental topaz; with green, Oriental emerald; with purple, Oriental amethyst. The adjective makes all the difference. The ordinary emerald, for instance, has as its basis *silica*, an oxide of *silicon;* and the ordinary amethyst is also silica, coloured by oxide of manganese.

Apart from its value, the true Oriental ruby is interesting on account of its extreme hardness, which yields only to that of the diamond, and, sometimes, to that of the sapphire, and also because it is found in very few places. In fact, nearly all the rubies ever mined come from a comparatively small district in Upper Burma, round Mogok, seventy miles north of Mandalay. Though rubies are occasionally found in Australia, Borneo, and Afghanistan, they are too few to affect the trade.

Little is known of the early history of the Burma ruby industry. It is said that Mogok and the neighbouring village of Kyatpyin were obtained in 1595 from a Shan ruler, in exchange for the town of Tagoung, on the Irrawaddy. Until 1885, that is, for nearly three centuries, the ruby ground was owned by the Burmese kings, who had such a liking for the "pigeon's blood" coloured stones, that the possession by a private individual of a ruby worth more than £70 was a crime, since any gem of that

value was considered to belong to the Crown. The obvious thing happened: that any one who found a big stone probably broke it up and sold it as several separate jewels. To prevent rubies going out of the country the ruby fields were forbidden ground to Europeans.

In 1885 Great Britain annexed Upper Burma, and the right of working the ruby grounds in the Mogok region not already occupied was granted to Messrs. Streeter & Co. at a rent of £26,666 a year, *plus* 16.66 per cent. of the net profits. They subsequently handed over their concession to the present Burma Ruby Mines Company, who hold a lease from the Government till 1932.

The area of the Stone Tract is 400 square miles, which sounds a very fine slice of territory. But when the Company's chief engineer arrived in Mogok he found that the pick of the country, *i.e.*, the valleys, was already occupied, and that he would have to confine his operations to the jungle-covered hillsides, without any indications of good ground to guide him. The labour supply was altogether inadequate, and the only means of communication with the outer world was a cart road sixty miles long leading to the Irrawaddy. In bad weather the road was a swamp. Of houses fit for Europeans there were none.

The Company proceeded to buy out the valley owners. Even then the water difficulties were such as to make them abandon the Mogok valley alto-

gether, and try their luck again in the Kyatpyin valley, eight miles distant. In the middle of this rises a conical peak with a Burmese name signifying the Hill of Spiders. "Long-legged spinners" have been associated with gold, and perhaps their presence is considered a good omen for the gem-seeker also. At any rate local tradition held that in the earth filling the hillside caves there existed the pigeon-blood ruby more abundantly than anywhere else.

Vigorous efforts were made to get at the *byon*, or ruby ground, in the caves and under the slopes at the base of the hill. It was even hoped that excavation might reveal a ruby-bearing volcanic "pipe" similar to those which contain the famous diamond blue-ground at Kimberley. By a curious stroke of luck the very first day's washing yielded a splendid stone, the only good one found here. The Spider Hill workings were in many cases tunnels driven into the hillside. This method of extracting *byon* didn't pay, as the actual number of miners was limited by the size of the heading. It was therefore determined to try washing over large masses of ground in a valley, that of Tagoungnandaing (what a terrible name!) being selected. Power to work the pumps and the washer was supplied by a water-wheel put half a mile off, and transmitted to the mine by an endless wire rope, according to the system then largely used in Switzerland. The results were quite satisfactory, for, in addition to a steady output of

small stones, the most valuable gem that has yet rewarded the Company, a fine stone weighing eighteen and a half carats in the rough, and eleven carats when cut, was exhumed. Unfortunately, the deposit soon gave out, and the machinery had to be moved again, this time back to the Mogok Valley.

Here, in a strip about two miles long and three furlongs broad, the ruby miners are now hard at work. The chief mines are the Shwebantha and Redhill at the north end, and the Choungzone at the south. Operations began in April 1894, since which date several millions of truck loads of ground have been washed over.

The method of working—the engineers hardly claim for it the name of system—is this. First of all, a pit is sunk, 10 feet square and 25 feet deep, and a centrifugal pump is placed in it. The ground all round is then gradually loaded into trucks and hauled away to the washer, any water encountered being led into the pit, from which the pump removes it. This process continues until the level of the mine reaches the bottom of the pumping pit, or the quantity of water exceeds the capacity of the pump: in which case it becomes necessary to sink the pit further and increase the pumping power.

The workmen are Chinese Shans, called Tayoks or Maingthas, who dress themselves in blue jackets and trousers, and live on rice, dried fish, salt pork, tea, and opium. The drug is said to be a necessity, for without it they "go to pieces," though when

Ruby sorters at work in the Ruby Mines, Burma. Natives sort the stones into fourteen qualities, under the supervision of an English mine official.

supplied they are good and willing workers. These men load the *byon* into trucks, which are hitched on to an endless rope, drawn up a slope, and tipped into the screens, through which, after being well shaken and disintegrated, it passes into the washing pans, 14 feet in diameter. Rows of steel teeth set in revolving arms churn up the clayey mass; the clay and lighter gravel run off into a safety pan; and the heavier gravel, containing the precious stones, is left behind—about one per cent. of the original contents of the washer.

At the end of each shift a door in the pan bottom is opened, and the deposit falls into trucks with covers, which are locked until the sorters are ready to treat the loads. The sorters tip the deposit into a large bin, also locked, from which it slowly dribbles into a revolving screen covered with different sizes of meshing. The sand is eliminated at once, and the clean deposit falls through in five sizes, the largest direct on to a sorting table, the other four into a pulsator, which further separates the heavier from the lighter stuff. No natives are allowed to handle the larger sizes,—the temptation might be too strong for their morals—and the English sorters conduct the next operation of working the stuff round and round in a sieve immersed in a tub of water till the rubies have gravitated to the bottom. The sieve is then smartly turned upside down on a table, so that the rubies are at the top and can be picked out by hand.

Every afternoon the day's find is taken to the office, where the inferior and worthless stones are handed over to the agent. Early next morning he sorts the largest stones himself, and watches while Burman helpers sort the rest into fourteen qualities.

The best stones go to the London market. The worst are sold by auction once a fortnight to local dealers. These are natural gamblers, and will run up prices if, say, they think that a lump of red corundum *may* have a valuable centre. Most probably it has not; but the *chance* makes them bid heavily against one another.

In the ruby ground are found spinels, which both in colour and general appearance closely resemble the true ruby. The best method of testing is to put the jewels under a dichroiscope, when the ruby shows two distinct colours if viewed from different directions; whereas the spinel and garnet show the same colour.

Besides the Company there are the native miners, who have to pay the Company a royalty of 20 rupees a month for every man they employ. The Company keep up a staff of English inspectors to see that they do not work with more men than licences have been paid for. The natives cannot, of course, go to the expense of pumps and patent washers, yet they manage to extract the stones very thoroughly. They either sink a pit into the *byon*, or follow it up through crevices in the rock, and bring the dirt to the surface to be washed in small baskets

and picked over by hand. A third method is to turn small hill streams on a deposit of *byon* and wash it down the hillside into a sort of "Long Tom," which holds the heavier constituents, but allows the rubbish to pass through.

Half the houses in Mogok are shops, where these traders may be seen squatting round a metal plate on which the stones for sale are displayed, haggling over prices. There is also a regular stone market outside the town.

The rainfall in this region is terrific. *Twenty-five inches* have been registered in four days in the valley: on the hills the precipitation was probably heavier! With great open pits to be kept free from the results of such deluges the engineers often find themselves in a difficulty; and it has been decided to drive a drainage tunnel through the hill on one side of the Mogok Valley which will not only curb the river flowing through, but also empty the water from the mines by gravity. The tunnel will be over a mile long and have a section of 7×7 feet. The water has, however, its uses. A dam has been built across the valley some distance below the town, to impound a lake, which is led through stone channels and pipes to the power-house, where three electric generators develop some hundred horse-power. On one occasion a landslip carried away the channel and piping, and by stopping the generators threw the mine pumps out of action, so that the mines gradually filled with water. To prevent the recur-

rence of such a disaster, the open channel has been replaced by a tunnel driven through the solid rock.

In addition to this electrically transmitted water-power, the Company have a good deal of high pressure water laid on direct to the machines. In the hills surrounding Mogok Valley ditches have been cut, starting from a mountain torrent and running along the hillside for miles till they reach the pipe lines which lead the water down to its work. Some ditches are the Company's own construction; others have been bought from native owners, who show great ingenuity in "contouring" the grade round the hills—and who expect a good price for their water rights.

Several rich valley deposits have not been touched as yet. And even when they have been worked over, there will still remain the hillsides, which are a fit subject for hydraulicing in the manner already described in our chapter on California.

The Railway Station in the third level of the Wieliczka Salt Mines, Galicia. At this point, several hundreds of feet underground, 25 miles of railway converge from all parts of the mine.

CHAPTER XXIII

SALT MINES

Salt—Its value as a dietetic—And distribution—Rock salt—Brine springs—The salt industry in Cheshire, Staffordshire, and Worcestershire—The salt mines of Wieliczka—A subterranean city—Art and industry combined—The day's work—Searching the miners for salt—The wonders of the mine—The Letow ballroom—Salt chapels—A vast chamber—A railway station in the depths—A saline Styx—The salt plains of Colorado—Ploughing the salt—A fine sight.

THE only mineral which figures in man's ordinary diet is salt. Almost from the earliest times of which we have any record the value of salt as a seasoning and digestive has been very distinctly recognised. Though man can live without salt, an instinct tells him to use it with certain kinds of food; and many species of animals also evince a passionate appetite for chloride of sodium.

This substance is, fortunately, very widely distributed. To begin with, the ocean is strongly impregnated with it, and on any sea-shore a supply may be easily obtained by evaporation. Many extensive deserts testify by their salt deposits to a time when the sea once covered them. But the most important source of salt is undoubtedly the rock-like strata which are found in many countries, sometimes outcropping as large hills of salt, sometimes sandwiched in between

strata of all geological ages except the earliest. It is curious that bitumen, coal, and petroleum often occur in proximity to salt; and some scientists go so far as to suppose that salt plays a part in the formation of the last. England is the chief salt-producing country: and Cheshire, Staffordshire, and Worcestershire are the counties where the largest deposits occur, Cheshire taking first place. Droitwich in Cheshire has been celebrated for its "wyches," or salt springs, ever since the Roman occupation, and the word salary (Latin, *salarium*) is due to the fact that salt was made a part of the Roman soldier's pay.

Salt has been made in England from natural brine springs for centuries, but the mining of the rock-salt deposits through which water must flow to become thus impregnated is a comparatively modern industry in these islands. The Cheshire beds were discovered in 1670 by men boring for coal, and have been mined ever since. The salt is sometimes so hard that it has to be blasted with gunpowder.

By far the largest proportion of English salt is the result of evaporating brine that has been pumped up from the surface of the rock-salt strata through large bore-holes specially made. About this system there is nothing at all romantic. The brine is merely poured into large open pans or tanks, heated beneath by furnaces, and the water is driven off until salt forms by precipitation and can be

drawn to the sides. If natural percolation is not sufficient to keep the brine wells filled with water, large quantities are poured down through bore-holes.

About two million tons of salt are produced yearly in England, Cheshire being responsible for more than three-quarters of the total.[1] The effects of the industry are very visible at Northwich and Winsford, where houses and chimney-stacks are so far out of the perpendicular, and the country so indented by depressions—often filled with water—that a visitor might easily imagine than an earthquake had passed that way. The "settling" of the surface, and of whatever it carries, is due to the constant removal of the salt down below, just as in coal districts the land overlying a bed sometimes sinks when the props or pillars in the workings give way.

Vast as are the English deposits, they must yield the palm for extent, if not for productiveness, to those of Wieliczka in Galicia, about nine miles from Cracow, which are deservedly the most famous in the world. In this region there is a mass of salt which is estimated to measure 500 miles in length, 20 miles in breadth, and 1200 feet in thickness! Wieliczka is the chief point of attack on this prodigious bulk. For nearly eight hundred years men have been hacking at the salt, and their labours have left a veritable underground city, which is one of

[1] The *Encyclopædia Britannica* says that the abstraction of salt from English beds amounts to *one cubic mile* every five years.

the "show-places" of Europe, often visited by Royalty itself.

As preface to a short account of these wonderful mines we should mention that they are the property of, and are controlled by, the Austrian Government, which derives no mean revenue from the sale of the salt.

In a coal, iron, silver, lead, copper, or mercury mine you may see many strange and curious sights, but none to compare with those of Wieliczka. The material which surrounds the visitor is eminently suited to fine effects, when illumined by electricity or candles—white salt sparkling with the prismatic hues of light from countless tiny facets. Recognising that a commercial undertaking could here be combined with magnificent artistic effects, the workers in these depths have, while removing some of the mineral, so decorated the face of what remains that now one may travel through and past chapels, altars, ballrooms, pillars, and thrones, all hewn from the solid rock salt. Salt staircases lead you from one floor to another. Chandeliers of salt hang from the roof. Statues of salt adorn the walls. Everywhere is salt, so skilfully shaped as to prove that the artistic feeling must be strong among the miners.

The mines have a length of about 2¾ miles along the bed, and there are eight levels. In the topmost three are the sights which tourists crowd to see; down below, the premises are for "business only."

Though it has been asserted that people have been born, and have lived all their lives in this subterranean city, there is no foundation for such a statement; unless, indeed, the writer has become confused between humans and horses, which last certainly do spend the whole of their lives from birth to death far removed from the daylight.

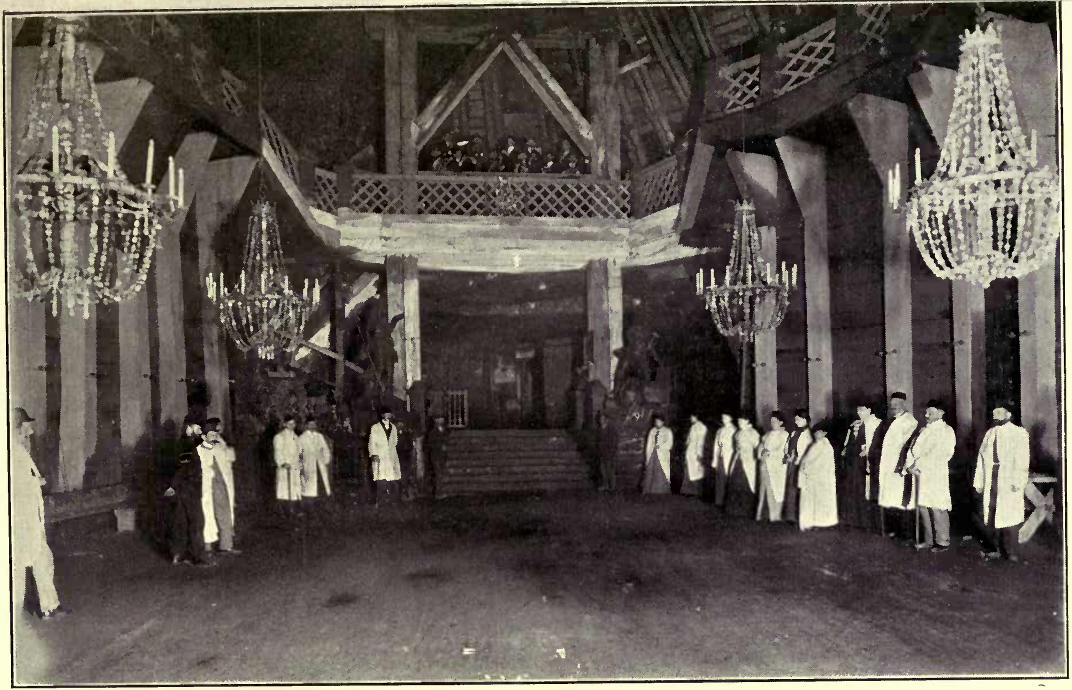
We may turn our attention first to the work of the mines, which is conducted by about one thousand miners. Working eight hours a day, they raise between them some sixty to seventy thousand tons of salt per annum, quarrying it out from immense chambers, which are carefully supported with timber-work in the roof. The chambers are duly named in honour of some well-known person, and act as store-houses in which to keep the salt until it can be drawn by rail to the central raising shaft of the mine. Such care is exercised in the excavations that accidents are very rare, though in the annals of Wieliczka there are recorded some terrible disasters, resulting from fire or the flooding of the mine by a subterranean lake. On account of the whiteness of everything around, the galleries are much more effectively illuminated by the miners' lamps than the workings of a coal mine; and the air is kept very pure by its contact with the mineral, so that both men and animals enjoy good health.

At the end of the day the miners ascend to the surface in lifts, and when all are up, the shafts are locked. One would hardly think that salt is a com-

modity worth stealing, or that, if stolen, the authorities would object to the theft of a mere pinch from an inexhaustible deposit. But salt is a taxable commodity, and it appears that at one time so much of it was smuggled out in boots and pockets that every man was searched when leaving work as if he were an employé in a diamond or gold mine. The practice is still continued, though in a perfunctory way, as the miners are too well paid to care about augmenting their income dishonestly.

Now for the wonders of the mine. Near the entrance stands a block of buildings, the offices of the manager, where visitors are kindly provided with overalls suited to the exploration of the caves below. The outfits worn by Royalty are carefully labelled with the name of the wearer and the date of the visit.

You can descend either in an hydraulic lift or by a staircase hewn out in the salt. "When the stranger reaches the mine there bursts upon his view a little world, the beauty of which is scarcely to be imagined. He beholds a spacious plain containing a kind of subterranean city, with houses and roads, all scooped out of one vast rock of salt, as bright and glittering as crystal, while the blaze of the lights continually burning for the general use is reflected from the dazzling columns which support the lofty arched vaults of the mine, which are beautifully tinged with all the colours of the rainbow, and sparkle with the lustre of precious stones, affording a more splendid



The Letow Ball-room, cut out of salt, in the Wieliczka Mines. It is 216 feet below ground, and has been the scene of many festivities presided over by royalty.

[To face p. 372.

and fairy-like aspect than anything above ground can possibly exhibit."[1] The illumination for spectacular purposes, by-the-bye, is carried out by the authorities on a specified scale, ranging from £5, 10s. downwards. For the highest figure all the electric lamps and candles in the mine are lit, and fireworks are let off to show the remoter corners.

The first level is 216 feet below the surface. It contains the famous Letow ballroom, excavated one hundred and fifty years ago, where many festive gatherings, presided over by the Emperor, have been held. "One end of the room is adorned with a colossal Austrian eagle, and with transparencies painted on slabs of salt. In an alcove at the other end of the room stands a throne of green, the crystals of which flash a green and ruby red. It is on this that the Emperor sits when he comes to the mines."[2]

Even older than the ballroom is St. Anthony's Chapel, close by, which dates from 1698, and may be considered the religious centre of the mines. It is reputed to be the work of a single miner, who has beautified it with many fine carvings, all executed in salt. Services are held regularly in the chapel, and on the 3rd of July there is a special mass, attended by many people, who flock in from near and far. There are other shrines and chapels, the finest being the Queen's, which, in addition to the splendid altar

[1] "The History of Salt," E. Martlett Boddy.
[2] *The Strand Magazine*, December 1898.

of salt, exhibits on one wall a view of Bethlehem, also worked in salt, while overhead hangs an elaborate salt chandelier.

In the second level is the Michelowitz chamber, 59 feet long, 92 feet wide, and 118 feet high, which has remarkable acoustic properties. The third floor contains a railway station, where the *twenty-five* miles of the mine tracks converge; and also a restaurant for the refreshment of visitors and workers. To quote the words of Mr. James W. Smith, who was responsible for the interesting description of the mines in the *Strand Magazine*, which has already been laid under contribution: "Five or six tables on one side of the line are often crowded with diners and drinkers of beer, who seem thoroughly to enjoy themselves under the hundred lights scattered over the front of the station. Several massive chandeliers of salt try to outvie in brilliancy the glow of the illumination from these incandescent lights. In some respects this scene, with its busy waiting crowd; its converging rails, its twinkling lights, and the rumble of the train in the tunnel near by, recalls the impression which one gets while standing at an English railway station on a moonless, starlight night."

As a contrast to the ballrooms, chapels, and station, there is a subterranean lake, navigated by a boat hauled along on a rope. In fact, there are sixteen lakes, but only one is included among the "lions."

Almost as remarkable as the Wieliczka Mines, though in quite a different fashion, is the wonderful salt farm on the Colorado River, where 1000 acres of solid salt are ploughed, hoed, and piled up as if it were mere earth. It occupies a depression in the midst of the Colorado Desert just north of the boundary line separating California from Mexico. This dip is 264 feet below sea-level, and in it salt has been deposited by the evaporation of saline water in past ages. About thirteen years ago the Colorado River overflowed its banks, dissolved the salt scattered in the depression, and when the water had evaporated there lay in the bottom of the basin a blindingly white sheet of the mineral. So intense was the glare from it that no person could venture on to it unless equipped with deeply-coloured glasses.

Its value being obvious, a company was formed to work the deposit. Never was salt more easily got. All that one had to do was to draw ploughs over the surface to loosen the salt, which could then be collected into heaps, and carted away as soon as all moisture had been dried out by the sun. A special plough was devised for the industry, a machine mounted on four wheels, with a heavy beak which cuts into the salt and piles it on either side of the track in two long ridges. It is pulled backwards and forwards by a rope operated by a steam-engine. So intense is the heat that Europeans cannot endure it, and Indians or Japanese have to be employed.

Even they suffer from optic inflammation, despite their coloured glasses; and also from a perpetual thirst, induced no doubt by the saline particles of which the air is full.

The deposit has a thickness varying from 1 to 8 inches. In places springs underlie the crust, but they are so impregnated with salt that they cannot dissolve any more, and therefore give little trouble. No sooner has a crust been removed by the plough than another begins to form, so that at present it appears as if the supply of salt were inexhaustible.

When thoroughly dry, the heaps are put on trucks and transferred to the mills at Salton, which grind the mineral into a fine powder, and otherwise prepare it for market, either as a table salt or for commercial purposes.

Though painfully brilliant during the daytime, the salt-field is a thing to be visited for its spectacular effects. A moonlight night should be chosen. Then "the spectacle is weirdly magnificent. The rows of glistening pyramids, the glitter of the moonlight from the facets of millions of crystals, the distant background of low, black hills, the expanse and stillness of the shadowless plain, strike one with awe and wonder that can never be forgotten."

CHAPTER XXIV

SULPHUR MINING

The uses of sulphur—Its occurrence—The sulphur deposits of Sicily—Popacatapetl—A romantic incident—A perilous adventure—Señor Corchado explores the crater—The miners at work—Mountains of sulphur in Japanese territory—Its exploitation—And removal—Grim surroundings.

SULPHUR can hardly be termed an article of diet, though in combination with treacle it is considered wholesome fare for children, if taken in small quantities. You may remember the dramatic episode recorded by Dickens in connection with Dotheboys Hall, when Wackford Squeers (junior) was stood on his head in a large bowl of the mixture by the infuriated victims of a bill of fare in which brimstone and treacle played too prominent a part. Sulphur has a medicinal value undoubtedly; but its chief uses are for the manufacture of gunpowder and sulphuric acid, and for the vulcanisation of india-rubber. It occurs chiefly: (1) as natural sulphur, almost pure, in the craters of volcanoes; (2) intermingled with earth and rock; (3) in combination with metals. We have already referred to the sulphides of mercury, silver, lead, and iron; from the last of which (iron pyrites) sulphur can be extracted in commercial quantities.

At present the great sulphur beds of Sicily yield the largest part of the world's supply. These are of volcanic origin. The sulphur mines of Catania, Girgenti, Palermo, and Caltanissetta give employment to some 30,000 people, and yield about 400,000 tons of sulphur a year. A network of galleries is driven through the deposits, and great chambers are hollowed out, often 100 feet high, central pillars being left for support. The ore is placed in stone-lined pits, having a sloping floor, covered up with rubbish, and lit at the top. The combustion of part of the sulphur produces sufficient heat to melt out the rest, which accumulates on the floor, and is drawn off into moulds holding about a hundredweight each. By this primitive method the ore is made to yield from 10 to 20 per cent. by weight of sulphur, according to quality. The neighbourhood of the kilns is to be avoided, as it is even less pleasant than the calcining district of the Rio Tinto.

There is probably no more extraordinary mine in the world than that worked for sulphur in the crater of Popacatapetl, 18,000 feet above sea-level. Nearly four hundred years ago a party of Cortes' followers, headed by Francisco Montano, made the terrible ascent to the crater in search of sulphur for the manufacture of gunpowder, as the supplies brought from Europe were exhausted. "The Spaniards, five in number, climbed to the very edge of the crater, which presented an irregular ellipse at its

mouth more than a league in circumference. Its depth might be from 800 to 1000 feet. A lurid flame burned gloomily at the bottom, sending up a sulphureous steam, which, cooling as it rose, was precipitated on the sides of the cavity. The party cast lots, and it fell on Montano himself to descend in a basket into this hideous abyss, into which he was lowered by his companions to the depth of 400 feet. This was repeated several times, till the adventurous cavalier had collected a sufficient quantity of sulphur for the wants of the army. This doughty enterprise excited general admiration at the time. Cortes concludes his report of it to the emperor (of Spain) with the judicious reflection that it would be less inconvenient, on the whole, to import their powder from Spain."[1]

But sulphur is scarce in Mexico, and the idea of robbing Popacatapetl's deposits was fascinating. Indians used to descend with baskets and gather small quantities, for which they found a ready sale. In 1850 a Señor Corchado thought that a regular mine might be established in the crater, and, accompanied by some Indians, and armed with an iron bar, ropes, and some sailcloth, undertook an expedition to the summit. The ascent was so toilsome that only Corchado and one Indian reached the top, where the former fainted through loss of blood and fatigue. The Indian, being unskilled in "first-aid," covered him up with the sailcloth, and started down

[1] "The Conquest of Mexico," Prescott. Book iii., chap. 8.

the mountain to get assistance. Meanwhile Corchado revived, and crawled a little way down the wall of the crater to escape the intense cold of the snowy slopes. The heat so revived him that he brought down the bar, sailcloth, and rope, with the intention of exploring the *horizontal,* or bottom, of the crater; and while he was engaged in fixing up his apparatus the relief party arrived.

Some *scoriæ* were collected and taken down to Puebla, where an analysis showed so large a percentage of sulphur that the crater was "denounced" as a mine. Capital having been raised, a rough tackle was rigged up for the use of workmen, and the hoisting of the mineral. Mr. R. A. Wilson, in his "Mexico," gives the following short account of a descent, which is sufficiently interesting to quote: "We followed a narrow footpath until we reached a shelf, where we were seated in a skid, and let down by a windlass 500 feet or so, to a landing-place, from which we clambered downward to a second windlass and a second skid, which was the most fearful of all, because we were dangling about without anything to steady ourselves, as we descended before the mouth of one of those yawning caverns which are called the 'breathing holes' of the crater. They are so called from the fresh air and horrid sounds that continually issue from them. But we shut our eyes and clung fast to the rope, as we whirled round and round in mid-air, until we reached another landing-place about 500 feet lower. From this point we

clambered down, as best we could, until we came among the men digging up cinders, from which sulphur, in the form of brimstone, is made."

The cinder deposits have been pretty well worked out by General Ochoa, who took over the mine, but sulphur is continually forming round the *solfataras*, or vents, of which there is a large number. Labour is somewhat difficult to obtain, as the working conditions are far from pleasant, though there is no special mortality among the men, who work in gangs, week and week about, and camp in rough sheds in the crater. When a storm or earthquake occurs their position is uncomfortable, but rendered tolerable by a judicious supply of spirits, and leaves of the *coca* plant, which enable the chewer to undergo great fatigue. In spite of the physical difficulties attending it, the Popacatapetl sulphur industry flourishes, or at least did so until quite recently. And if the proprietor still makes a good profit he certainly deserves it.

Another interesting sulphur region is situated in the realms of the Mikado, on a little island half-way between the most northern point of the Japanese mainland and the southernmost point of Kamchatka. The island, named Etrofu, contains three volcanic mountains, about 3000 feet high, of almost pure sulphur. Volcanic vapours, pouring through countless fissures in the ground as well as from the craters, are perpetually increasing the deposits, which have been calculated to total over *two million* tons of pure mineral.

Early in May 1898, some enterprising Japanese prospectors suggested to a firm of American engineers who had their headquarters at Yokohama, that they should join forces to mine this vast accumulation of valuable material. Concessions were got from the Japanese Government of several square miles including this, the most extensive sulphur deposit in the world, and a preliminary survey of the locality was made.

The island lies off the regular ocean routes, and is so far north that its coasts are ice-bound for half the year. A surveying party, accompanied by Japanese engineers and a guide, sailed from Yokohama to Moyoro Bay, near the volcanoes, and after suffering great privations, discovered that the immense sulphur cones lay about two miles from the coast, though fortunately there was a natural decline leading gently down from the mountains to the excellent anchorage of Moyoro.

This being so, the transport of sulphur from the deposits to ships could easily be effected by means of a cable-way carried on large trestles. As soon as the winter snows had melted in 1899, Mr. E. W. Frazer, a New York engineer, arrived at Etrofu, with a large gang of Japanese labourers, tools, timber, wire rope, and other supplies, to exploit the property in the interests of the Company formed with Japanese and American capital. Five months of hard work saw the completion of a rope transmission plant from the base of the sulphur cones to the sea level, and of buildings to house men and material.

The next year the plant was put in full working order. The yellow crystals were dug out of the hill and shovelled into iron buckets suspended at intervals of 300 feet from the cableway, which ran down to the sea on one side of the trestles and back again on the other, so as to form an endless rope. The weight of the full buckets keeps the rope in motion, the empty buckets being returned on the up-track by the descent of the full ones. The speed of travel can be regulated by friction brakes acting on a drum round which the cable passes at the upper terminus.

In the course of five months 10,000 tons of sulphur were mined and transported to sea-level; and 6000 tons were shipped to the refinery at Hakodate, Japan. The quantities mined annually have since increased, but it will take many years to approach even appreciably the exhaustion of the supply which Nature has so generously included within the domain of the Chrysanthemum.

Sterility and desolation are distinguishing features of a neighbourhood where sulphur abounds. The fumes utterly destroy vegetable life. We have already had a picture of a sulphur Inferno, but the following short description from the pen of Mr. William H. Crawford[1] is interesting, and therefore may be fittingly reproduced. "The writer's first view of the deposits, after a long and tedious trip, showed clouds of steam pouring from several places near the summits of the hills, and far down along the sides

[1] In *Cassier's Magazine*.

glistened immense patches of dull yellow, which were occasionally lost to sight as a fickle breeze wafted the vapours in such a way that the brighter yellow sulphur of the summit could be seen. . . . On climbing to the top, the hills were found to consist of almost pure sulphur, inasmuch as diggings at every conceivable place brought up the yellow crystals. The sulphurous vapours which poured from subterranean depths were suffocating, and, instead of issuing from only a few places, as it seemed when viewed from a distance, the whole cap of each hill was really honeycombed, and each outlet was continually adding to the stock of the whole, day by day, as the vapours were condensed."

CHAPTER XXV

THE PERILS OF MINING

Dangers incurred by the miner—Fire, falls, poisonous gases, and disease—Falls—Safety catches for cages—Fire-damp—Choke-damp—White-damp—Ventilation the surest safeguard—The safety lamp—Electric lamps—The Wattstown disaster—One hundred and twenty lives lost—Other notable disasters—Extraordinary endurance of entombed persons—John Brown—Giraud—The Snaefell lead mine disaster—A dramatic account of the effects of white-damp.

"How wearisome and painful the life of a miner is at best, only those who have earned their bread in underground prisons can know. From the most ancient times, writes Gamboa, the toils of the mine have served as a punishment for slaves, a torment for martyrs, and a means of revenge for tyrants. According to the grave description of Plautus, mining is attended with every pain that hell can inflict, and, indeed, that poet considers the torments of hell less insufferable. The crown laws of Spain appointed the raising of ore as an appropriate punishment for vagabonds, being an occupation of incessant labour, and continually exposed to imminent risks, in view of which it is said that the Belgians named a mine shaft *la fosse* (the grave) intentionally, and in Cornwall the old open workings on a lode were called coffins, if Simonin's record is to be trusted."[1]

[1] "The History of the Comstock Lode," ii. 211.

The conditions under which mining, taken as a whole, are now conducted are such as to render some of the above words inapplicable to the modern industry. Only in a very few parts of the globe are criminals condemned to drag out their lives in subterranean prisons, urged by the lash of brutal taskmasters. The abuses which once made the coal mines notorious have been swept away; and in all kinds of mines rules and regulations safeguard the health and life of the miner.

There still remain, nevertheless, a sufficiency of dangers to render the miner's calling a distinctly hazardous one. The coal miner, in particular, runs daily risks, for in addition to the falling roof, the inrush of water, the overwound cage, the broken rope, and the premature explosion of blasting charge, he incurs the fearful perils of asphyxiation and fire. We must further remark that, besides the more sudden and dramatic calamities which may overtake the miner, he is subject to the subtle but no less deadly attacks of disease—pneumonia, arising from sudden changes of temperature; consumption, caused by inhaling dust; and "miner's worm," a disorder of the intestines.

The falling-in of the roof of a mine can be prevented only by the greatest care in leaving proper pillars, or by a system of strong timbering. The science of roof-staying is now so well understood, that few extensive disasters occur from premature caving-in. Generally a fall is heralded by unmis-

takeable signs—cracking in the roof, the flaking off of small pieces, the bulging of pillars and timbers—which give the men fair warning. When a fall does take place, its effects are not limited to the area immediately underneath ; for the sudden expulsion of air through the galleries has been known to lift cars from the track and smash them against the walls, and even to sweep away the timbering of the galleries. A case is recorded in which a man was sitting at the entrance to a level eating his dinner, when a fall occurred in a distant chamber. The air-rush caught him and dashed him so violently against a wall of coal close by that he was killed on the spot.

We seldom hear nowadays of a cage falling down a shaft ; for not only are the steel hoisting ropes very durable and trustworthy, but every cage is also provided with a safety catch which, in case of the rope breaking, comes into action and jams its teeth into the cage guides. (sometimes)

The most deadly foes of the coal miner in particular are the gases given off by coal. Bituminous coal gives off carburetted hydrogen, or marsh gas (CH_4), the result of vegetable decomposition under water. Some of this gas was imprisoned during the formation of the coal, and being under high pressure, is ready to escape when a miner opens a crevice in which it has collected. Sometimes a large body of the gas is suddenly tapped, and rushes out into the workings. Being only half as heavy as air, it natur-

ally rises to the roof, and when mixed with from four to twelve times its volume of atmospheric air becomes highly explosive. Should it then come into contact with a naked light, the effects are fearful; almost comparable with those of gunpowder. A terrible flood of fire rushes through the galleries, scorching and igniting anything it meets. A loud report at the pit-head, accompanied by smoke and flying fragments, tells those above that a pitiable disaster has overtaken those below. The "fire-damp," as the carburetted hydrogen is called by the miners, leaves a deadly residue behind it—"choke-damp," or carbonic acid gas, the product of combustion, which, being heavier than air, sinks to the bottom of the levels and galleries, and speedily suffocates any living thing it encounters. The miners may escape the actual explosion, by flinging themselves on their faces, while the conflagration rushes overhead; but unless they are soon on their feet and manage to reach a part of the mine not swept by the flames, the choke-damp will claim them as victims.

A third gas, carbon monoxide, or "white-damp," is even more fatal than "choke," or "black-damp." It is the result of imperfect combustion. Even if it does not kill on the spot, it has more or less permanent effects on a person who has inhaled it, as it is most difficult to expel from the system.

The best safeguard against explosions and suffocations is continuous ventilation of all workings. In

old times a miner, called the "penitent," on account of the resemblance of his dress to that of a cowled monk, was sent through the workings of some mines, after the other miners had finished their day's labour, armed with a lighted taper to ignite any small bodies of fire-damp that might have accumulated during the day. Sometimes he met a dangerously large volume, with results fatal to himself; so that the office of "penitent," or "fireman," required a brave man to fill it.

Before ventilating machinery and methods were sufficiently perfect to thoroughly scour the mines, the safety lamp, invented by Sir Humphrey Davy and George Stephenson, was of prime importance, and even now is the only form of lamp used in many mines. The flame is encased with a wire gauze cylinder having 784 apertures or meshes to the square inch. Under ordinary conditions flame will not pass through a gauze of this kind, as the heat of gas burning on one side is rapidly dissipated by the wire. The presence of a small percentage of fire-damp is shown by the behaviour of the flame, which becomes smoky. If the percentage is high, the cylinder becomes full of a pale blue flame, and the lamp grows so hot that it must be removed beyond the gas zone as quickly as possible.

In spite of this useful invention many disastrous explosions have occurred, generally through carelessness on the part of a miner who opens his lamp to light a pipe or another lamp that has gone out.

Constant association with danger makes men reckless and ready to "take the chance."[1] Even if the lamps are padlocked some one may have a key that fits them. In some mines, therefore, a magnetic lock is fitted, consisting of an iron plunger forced into a recess by a strong spring, locking the two parts of the lamp together. The lamp can be unlocked only by placing the lamp over a powerful electro-magnet, kept at the lamp station, which overcomes the force of the spring and draws down the plunger. Electric devices are also used for lighting the lamp without re-opening it.

In the future the oil lamp will doubtless be replaced by the electric portable lamp, supplied with current from a small accumulator or a primary cell forming part of the apparatus. Accumulator, or secondary battery, lamps, are popular on the Continent, and have been introduced into some Durham collieries. The objection alleged against them is that they do not give warning of fire- or choke-damp, being quite independent of the outer atmosphere.

Whether this is a reasonable objection may be doubted. Yet it was in a mine of which the galleries are lit by electricity—the Wattstown Colliery in the Rhondda Valley, Glamorganshire—that one of the most terrible mining disasters of recent years occurred. At 12.30 p.m. on Wednesday, July 12,

[1] Faraday once watched the preparations for a blast being made in a mine by the light of a candle stuck in a lump of clay on the floor close to a sack. "Where's your gunpowder?" he asked. "That be it you're settin' agin," replied the man, pointing to the sack in question!

1905, a tremendous explosion in the "up-cast" shaft threw the village of Wattstown into a panic. The sound was compared to that of the discharge of a park of artillery; and its force was such as to break windows in houses hundreds of yards away.

At the time 121 men, including the manager of the mine, Mr. W. Meredith, were at work in No. 1 pit (the "up-cast"), and nearly 1000 in No. 2 pit (the "down-cast"). News of the disaster spread like wildfire. The mountain roads were soon alive with people hurrying to the pit-head to get news of friends and relations who might have been entombed. Colliery managers and medical men for miles round left their work and hastened to give what help they could.

The force of the explosion and its after effects had fortunately been confined to the "up-cast." Amid most pathetic scenes all the workers in pit No. 2 were brought safely to the surface. But from the other shaft there came no reply in answer to the many signals sent down, and the worst was feared. The pithead gear had been wrecked by the explosion, and the ventilation shaft badly damaged, so that it was some time before rescuers, plenty of whom are always ready to risk their lives in the service of humanity, could descend. At the shaft bottom four men were discovered, two still alive. One of these died shortly after being brought to the surface. The other, Matthew Davies, a lampman, was the only survivor of the 121 men who went down the

shaft for the morning shift. He owed his life to his presence of mind in wetting the collar of his coat and holding it over his mouth to exclude the choke-damp. Proceeding along the air-ways, the relief party found ten bodies, including that of Mr. Meredith, and then were brought to a halt by a fall of roof. When the debris had been pierced, seventy more bodies were discovered, some terribly mutilated, others in a sitting posture and uninjured. One of the relief party said that bread and cheese lay about, and that the men were evidently having their dinner when the accident occurred. In most cases death must have been practically instantaneous. One old miner lay as if asleep, his features perfectly calm and undisturbed, though a leg had been broken in two places.

Thus, in a few moments, 120 lives had been blotted out. Such a calamity might be expected to scare many men from earning their livelihood under conditions which render a like fate possible for them. But no! Explosions, falls, and floodings all come "in the day's work," and are soon forgotten. The miner is somewhat of a fatalist: and, after all, the percentage of deaths from accidents among his class is low, considering the risks.

Terrible as the Wattstown disaster was, it by no means represents the most tragic episode of its kind. In 1857 180 men were killed by an explosion at Lundhill Colliery; and at Oaks Colliery in October 1866 no fewer than 364 poor fellows perished.

Even more tragic than an explosion, which is usually mercifully swift in its effects, is the walling-up of a party of miners by a "fall." We have already mentioned the Hartley Colliery disaster which shocked the world in 1862. The beam of the pumping-engine broke and fell down the shaft, killing on the spot five men who were ascending in the cage. Had the deaths been limited to that number, little notice would have been taken of the affair. But, unfortunately, the forty-ton iron beam on its way down detached large lumps of the shaft wall, and an impenetrable mass of wood and rubbish accumulated at a point 138 yards from the surface, sealing the only means of egress for the 199 men and boys below. These all perished from suffocation, though desperate efforts were made to reach them.

Two instances are on record in which entombed persons have lived for extraordinary periods without food. In October 1835 a big fall took place in the Kilgrammie pit, of the little Girvan coalfield, Ayrshire. All the men escaped except one, John Brown, who returned to fetch his jacket and had his egress blocked by a second smaller fall. A fortnight later search was made for his body, and the searchers thought they heard groanings. That poor Brown could still be alive they could hardly believe, and accordingly attributed the noises to his spirit. However, the attack on the fall was continued, and on the twenty-third day after the accident the open

workings beyond were reached. Here they found Brown, *still alive*, but so wasted that his backbone could be felt by any one laying a hand on the pit of his stomach. When the poor collier reached the light of day his body and beard were seen to be covered over by a fungus that grows upon decaying timber props, a sight never seen before! But the rescue had come too late, and in three days poor Brown died.

His remarkable record of endurance, cut on the stone which marks his grave in Bailly churchyard, is eclipsed by that of the well-sinker Giraud, who, with a companion, was entombed for *thirty days* in the bottom of a well near Lyons.

To reach them it was necessary to sink a second shaft and drive a cross-heading, a very slow operation, which would not have been persevered with had not the workers been encouraged by tappings below. All Europe watched the extraordinary fight with death that plucky Giraud made. His comrade died, and his body lay rotting at his side. On the thirtieth day Giraud was extracted, his body a mass of gangrenic sores from contact with the corpse. Like Brown, he had lived only to die a few days after his rescue.

An extraordinary instance of "white-damp" poisoning occurred in 1898 at the Snaefell lead mine, the Isle of Man. It is remarkable from the fact that several people, including Professor C. le Neve Foster, one of the Royal Inspectors of

Mines, were almost asphyxiated, but, being rescued in time, recovered and have recorded their personal experiences.

It appears that a fire took place among the timber of the 130-fathom level, owing probably to a lighted candle being carelessly allowed to touch a prop. The combustion produced the deadly carbon monoxide, which killed twenty miners. Two days after the accident Professor le Neve Foster, with three other men, descended the mine to test the air. What happened will best be given in the words of the Professor's personal report to Her Majesty's Secretary of State, which is at once extremely interesting and pathetic:—

"On the 13th May I did not notice any unpleasant symptoms while in the mine, but after having been on the surface for a little time I had a decided headache across the forehead. On the following day we did not go down below the 100 level, and felt no inconvenience whatever in any shape or form. On the 15th there was certainly a feeling that the air as we descended was less good than on the previous day; but this in no way interfered with my work, such as testing the air from platform to platform below the 115; nor was my power of deciding that it was unsafe to descend to the corpse itself in any way impaired. I cannot recall any symptoms undoubtedly due to carbon monoxide, until I reached the 115 level after having climbed

rapidly up the ladders, when Captain Kewley gave the alarm that he was feeling ill. The poison took effect most suddenly; probably its action was accelerated by the exertion of climbing rapidly. I felt decidedly queer when I reached the level, and thought a drop of brandy might revive me; I took out my little brandy flask, but already my fingers seemed incapable of doing the work properly, and some one unscrewed the stopper for me; I took a small sip and sat down. Everything then seemed in a whirl, and the atmosphere seemed to be a dense white fog. This must have been, as far as I can judge, a little before 1 p.m., for we went down precisely at noon, and allowing full time for the descent and testing the air from platform to platform below the 115, I do not think an hour had elapsed after leaving the surface before we were taken ill.

"Sitting next to me was Mr. Williams, and within a few feet were Captain Reddicliffe and Henry Clague; the men who had remained all the time at the 115 level, or at all events had not descended as low as we did, had started to climb to the surface, but of their starting I have no recollection. A curious fact is that we all sat without moving or trying to escape; the foot of the ladder was close by, yet none of us made any effort to go to it and ascend even a single rung. We none of us tried to walk a dozen steps which would have led us to the other side of the shaft partition, where we all knew that there was a current of better air. We simply sat on

and on; Mr. Williams remained motionless like a statue; Captain Reddicliffe, on the other hand, was shouting and groaning nearly all the time, while Clague was moving his arms. Of all this I was perfectly conscious, though rooted to my seat. By my side was one of the pipes conveying compressed air, in which a hole had been punched some days before. I was perfectly conscious that fresh air was a good thing for me, and I frequently leant over and put my mouth to the hole and inhaled a good breath. How soon I realised that we were in what is commonly called 'a tight place' I cannot say; but eventually, from long force of habit I presume, I took out my note-book. At what o'clock I first began to write I do not know, for the few words written on the first page have no hour put to them. They were simply a few words of good-bye to my family badly scribbled. The next page is headed '2 p.m.,' and I perfectly well recollect taking out my watch from time to time. As a rule I do not take a watch underground, but I carried it on this occasion in order to be sure that I left the rat long enough when testing with it. In fact, my note on the day of our misadventure was, '5th ladder. Rat two minutes at man,' meaning by the side of the corpse. My notes at 2 p.m. were as follows:—
'2 p.m., good-bye, we are all dying, your Clement, I fear we are dying good-bye, all my darlings all, no help coming, good-bye, we are dying, good-bye, good-bye we are dying, no help comes, good-bye,

good-bye.' Then later, partly scribbled over some 'good-byes,' I find, 'We saw body at 130 and then all became affected by the bad air, we have got to the 115 and can go no further, the box does not come in spite of our ringing for help. It does not come, does not come. I wish the box would come. Captain R. is shouting, my legs are bad, and I feel very [1] , my knees are [1] .' The so-called 'ringing' was signalling to the surface by striking the air-pipe with a hammer or bar of iron. We had agreed upon signals before we went down. There is writing over other writing, as if I did not see exactly where I placed my pencil, and then: 'I feel as if I were dreaming, no real pain, good-bye, good-bye, I feel as if I were sleeping.' '2.15, we are all done. No [1] , or scarcely any, we are done, we are done, godo bye my darlings.' Here it is rather interesting to note the 'godo' instead of 'good.' Before very long the fresh men who had climbed down to rescue us seem to have arrived, and explained that the 'box' was caught in the shaft. Judging by my notes I did not realise thoroughly that we should be rescued. Among them occur the words 'no pain, it is merely like a dream, no pain; no pain, for the benefit of others I say no pain at all, no pain, no pain.' I frequently wrote the same sentence over and over again. My last note on reaching the surface tells of that resistance to authority

[1] Word illegible.

which likewise appears to be a symptom of the poisoning.

"These notes afford ample confirmation of the effect produced by carbonic oxide poisoning of causing reiteration. I wrote the same words over and over again unnecessarily. The condition I was in was rather curious. I had absorbed enough of the poison to paralyse me to a certain extent and dull my feelings, but at the same time my reason had not left me.

"The general sensation was like a bad dream, and yet I was able to reason properly and write intelligibly, though in a disjointed fashion.

"I have been asked whether some of my notes may not have been written automatically or unconsciously. If there had merely been a good-bye to my wife and children I might have been doubtful on the subject, as I find that in my note-book I used some wording identical with that of a letter addressed to my wife which I had written as a matter of prudence before leaving Laxey on the morning of my first descent. After my visit to the mine on the previous afternoon, I knew there was some risk to be encountered, and I simply penned the letter for use in case things should go wrong. Fortunately, the letter was not wanted. Wholly apart from my farewells, it seems to me from my notes that I was recording things correctly, and that my brain was reasoning properly; I do not think I ever lost consciousness in the mine.

"Mr. Williams, on the other hand, and Captain Reddicliffe, though not absolutely unconscious, did not recognise the lapse of time, for they thought that only about ten minutes passed between my calling out 'All up at once,' and their arrival at the surface. In reality, nearly two hours had gone by.

"That the numbness of the fingers recorded in my notes was no fancy is proved by the fact that I burnt my wrist and hand with my candle while sitting underground, and had no notion that I had done so until a friend in the evening called my attention to a big blister. I daresay this was five hours or more after the burn.

"I think there certainly was a feeling of exhilaration on reaching the top of the shaft; I was quite able to walk and was in full possession of my senses, for I at once asked Dr. Miller to take a little of my blood, so that it might be tested spectroscopically. He tied a bandage round my arm, and when one of my veins was well swollen he inserted a hypodermic syringe, but no blood could be drawn. He then tried Mr. Williams in the same way, but again without success. That the puncture was deep is proved by the scar, which is still apparent. About an hour after I came up I sent off a telegram to my wife, which I reproduce in order to show that the effects of the carbon monoxide in producing unnecessary repetitions had not worn off: 'Am perfectly right, do not believe any report to the contrary; I repeat

I am perfectly right.—Clement. Address, Peveril, Douglas.'

"Though feeling quite able to walk to Laxey, a distance of about four miles, I took the advice of Dr. Miller and went down with some others in a trap. One of the miners who was with us was vomiting from time to time, and by and by I felt a desire to be sick also, and put my finger down my throat with the idea of assisting nature, but without effect. Soon after this I became unconscious for a few minutes; it was not a true fainting, but something of the nature of an epileptiform seizure, as I am told that I was a little convulsed, though I never had anything in the nature of a fit before. Dr. Haldane has pointed out that seizures of this description are not uncommon after carbonic oxide poisoning. On getting to the hotel at Laxey I laid down on the sofa with a headache, and Mr. Williams suffered from headache and vomiting.

"On arriving at Llandudno three days after the accident, I happened to pass our family doctor, and he told me afterwards that he at once noticed that the colour of my face was strange.

"A few days after I got back from the island the first time, about the 21st or 22nd of May, I noticed my heart; it could scarcely be called palpitation, as I understand palpitations to be, for there did not seem to be any increased rapidity of its action, but I was conscious of its beating; as a rule, I am not. This passed off, and then on 1st and 2nd of June

I noticed it very decidedly again, so much so that I went to my doctor. He sounded me, and said the heart was all right, though there was one sound which was not very distinct. This consciousness of having a heart still returns from time to time, though only to a slight extent. On the 19th May I suffered much from headache, not regularly, but intermittently. The headache lasted for several days, and the feeling in the legs was very apparent; it was an aching in the legs from the knee to the ankles. A coldness from the knees to the soles of the feet was also noticeable; it came on occasionally for a considerable time. The headaches continued at intervals for some time, and lasted certainly for some months after the accident; indeed, I cannot say that they have disappeared altogether. Whether these headaches are still a consequence of the poisoning or not, I am unable to say. I have, at the risk of being wearisome, given the above account of the mental phenomena accompanying partial poisoning by carbonic oxide, because it is possible that they may be of assistance to those who are investigating the subject from a scientific point of view."

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